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ABSTRACT

Data which had significance for design and drafting curriculums were collected by direct observation of 21 design and drafting factors within 16 selected industrial companies employing 869 designers and draftsmen. Observations covered (1) the number of design and drafting employees, (2) the system of drafting room organization, (3) job classifications, (4) hiring, training, and promotion practices, (5) physical facilities, (6) drawing materials, standards, and special devices and techniques, (7) methods of handling change orders and checking and storing drawings, (8) women in the occupational area, and (9) unique detail drafting practices. The companies observed were engaged in (1) electro-mechanical design and drafting, (2) mechanical design and drafting, (3) civil, structural, and architectural drafting, (4) technical illustration, and (5) tool design. Job classifications and hiring practices varied from company to company. Usually three grade levels were provided for both designers and draftsmen. Larger companies seemed to be more flexible in hiring younger and more inexperienced personnel, and several companies required preemployment tests. Military standards and the American Standards Association documents were widely used. Two of the 16 companies were experimenting with computer devices to automate drafting and several other unique drafting practices were observed. About 5 percent of the designers and draftsmen were women. Most chief draftsmen were seeking training for employees and potential employees. It was recommended that there be more interaction between instructors and industry. The appendix includes equipment guidelines, a preemployment test, a draftsman rating guide, and the observation report form. (EM)

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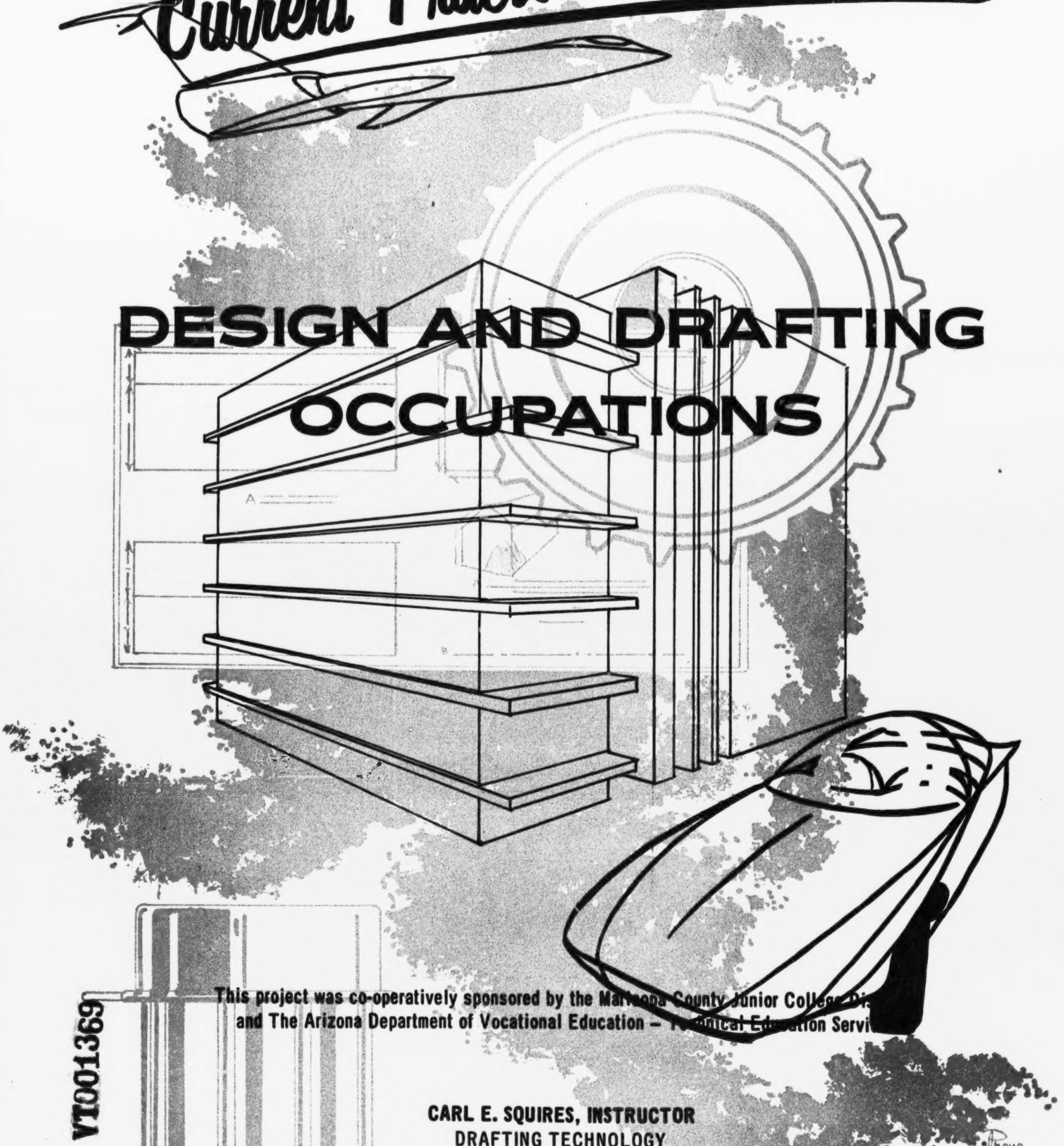

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GLENDALE, ARIZONA

SUMMER 1966

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Carl E. Squires, Instructor
Drafting Technology
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Glendale, Arizona

Summer 1966

PREFACE

The purpose of this booklet is to present observed information related to current practices utilized in a cross section of design and drafting occupations within Maricopa County, Arizona. It is expected that these observation reports will enable design and drafting teachers throughout the state of Arizona and elsewhere to up-date their knowledge of current practices without their employment in each of the design and drafting occupations.

This project was jointly sponsored by the Maricopa County Junior College District and the Arizona Department of Vocational Education-Technical Education Service in cooperation with sixteen industrial companies that provided observation opportunities in a general cross section of design and drafting occupations. Project headquarters was at Glendale Community College. Duration of the project was ten weeks.

The writer gratefully acknowledges his indebtedness to the following individuals who have influenced the preparation of this booklet: Mr. J.R. Cullison, State Director of Vocational Education; Mr. R. Dean Frey, State Supervisor of Technical Education; Dr. Irwin L. Spector, Director of Research and Curriculum, Maricopa County Junior College District; and Dr. John F. Prince, Dean, Glendale Community College.

In addition, a special word of thanks is due to the following companies for their interest and participation in the project: AiResearch Manufacturing Company; Allison Steel Company; Arizona Highway Department; City of Phoenix Planning Department; Del Webb Corporation; Dickson Electronics; General Electric Company; Goodyear Aerospace Corporation; Lescher and Mahoney, Architects; Maricopa County Highway Department; Motorola, Incorporated; Paramount Designs Incorporated; Rocket Power, Incorporated; Salt River Project; Sperry Phoenix Company; and Techni-Builders, Incorporated.

Early in the preliminary contacts with the companies providing observational opportunities for this study, it became obvious that several companies for various reasons did not wish to have their names published in connection with a study of this nature. Since the practices of individual companies are not an issue in this study, it was decided that company names would be omitted in the body of the writing. The reader should also be aware that in most cases the end product of each company is different, therefore, the drafting and design practices utilized successfully by one company cannot be economically used by another company.

Not all occupational areas of design and drafting were observed, nor did time permit in-depth observation of several areas selected. This study involved 869 designers and draftsmen.

Carl E. Squires

Phoenix, Arizona

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CHAPTER I

RATIONALE AND PROCEDURES

It is in the interest of sound educational practice for teachers of design and drafting technology to remain current in their subject matter field. Communication between education and industry appears to be a key factor in maintaining this status. Several methods have been utilized to facilitate this line of communication and to up-date teachers in the current practices utilized by industry. These methods have included: study of trade and professional journals, speakers from industry, visits to industrial plants, seminars, and summer work experience within an industrial firm. Of the methods presented, the summer work experience within an industrial firm has been most useful in upgrading teacher competency in design and drafting technology. Yet, as the occupational areas of design and drafting have broadened and have become increasingly complex it has become most difficult, if not impossible, for a drafting teacher to remain current within his general teaching field through work within a single industrial firm during the summer months. The possibility of a teacher obtaining experience within several design and drafting occupations within a short period of time is ruled out because most industrial firms, due to economic necessity, are reluctant to hire personnel for a period of less than three months.

Nevertheless, design and drafting teachers are expected to remain reasonably up-to-date in the practices utilized in several design and drafting occupations, for example, mechanical design and drafting, architectural drafting, structural drafting, electro-mechanical design and drafting, technical illustration, and tool design. Knowledge of current practices related to these occupational areas is particularly required by teachers assigned to instruct in the basic exploratory courses in design and drafting technology, and in programs where enrollment and teaching staff do not justify narrow specialization within the subject matter field.

If design and drafting teachers are to keep abreast of current industrial practices, unique approaches to the acquisition and disdemination of current knowledge related to these practices must be found. This project was developed on the premise that a single investigator, observing current practices within a cross section of design and drafting occupations could collect, compile, and distribute data related to current industrial practice that would be of significant value to a large number of design and drafting teachers who, because of a lack of time and other factors, were unable to personally collect similar data.

In analyzing the need for this project the writer conducted a tentative search of technical and professional literature. In addition, a review was made of the technical education projects supported by the U.S. Office of Education. Review of literature revealed several direct observation in-plant material gathering activities; however, these have generally been directed to data collection as relates to curriculum construction and personnel needs rather than to current industrial practices utilized in design and drafting occupations. Several mail correspondence surveys related to technical drafting programs were reported. A significant survey of the correspondence type was conducted by an Arizona educator during the summer of 1965. This survey, which covered design and drafting activities throughout the state, is comprehensive and informative. A reading of this document will provide much valuable information for design and drafting teachers.[1]

Investigation also revealed the need for teachers to become current in their knowledge of industrial practice. An example of this need is evidenced by the local and national efforts that are being made to up-date design and drafting teacher competency. The American Institute for Design and Drafting has recently conducted a series of nationwide seminars for this purpose. Local workshops sponsored by large manufacturing firms have also been held for this purpose.

---

[1] Suggestions From Industry Concerning Improvement of Technical Drafting Programs in the State of Arizona, Oliver, Dan   Arizona Western College, 1965

Source: State Supervisor of Technical Education
Arizona Department of Vocational Education
412 Arizona State Building
Phoenix, Arizona

The procedure used in the collection of data for this booklet involved the following steps:

1. The writer selected a group of sixteen industrial companies that employ design and drafting personnel and which represent a general cross section of industrial activity within a metropolitian area of approximately 875,000 population (Maricopa County, Arizona). This area, in which at least 1,200 designers and draftsmen are employed, provides a broad spectrum of design and drafting activities.

2. Preliminary contact with these companies was made and acceptance of this project was assured by the responsible industrial administrative personnel involved. Coordination of observation time blocks was then completed.

3. Direct observation of design and drafting practices within the selected companies was made. In several cases the writer spent a week within a single company. In other cases less than a day of observation provided the desired information. In addition to direct observation, interview time was granted by design and drafting supervisors, engineers, and draftsmen.

4. An observation report instrument was used to facilitate collection of data. Factors observed in the design and drafting occupations included:

   1. Number of employees in this occupation within this company___
   2. System of drafting room organization___
   3. Job classifications___
   4. Hiring practices___
   5. Training practices___
   6. Promotion practices___

7. Physical facilities —
8. Furniture —
9. Equipment —
10. Drawing material —
11. Drafting room manual and other references used —
12. Standards used —
13. Observed use of templates, appliques, lettering aids and other time saving devices —
14. Use of ink in this area —
15. Simplified drafting practices observed —
16. Computer devices used in this area —
17. Method of handling change orders —
18. Method of checking drawings —
19. System of storage of drawing data —
20. Number of women employed in this occupational area within this company —
21. Unique detail drafting practices (practices that are not commonly published in design and drafting textbooks) —

The observation reports are presented in this booklet. A brief summary is provided at the end of each occupational area observed. In the latter part of the writing some general observations, conclusions and recommendations have been made. The recommendations are directed primarily to persons charged with the task of educating personnel for positions in the areas of design and drafting.

It is hoped that this work will stimulate and guide similiar endeavors in other fields of technology. Detailed information related to how the project was accomplished will be provided to interested persons upon request.

Please address inquires to:

Carl E. Squires, Chairman
Division of Applied Sciences
and Technologies
Glendale Community College
6000 West Olive Avenue
Glendale, Arizona

CHAPTER II

ELECTRO-MECHANICAL DESIGN AND DRAFTING

This area of design and drafting involves the generation of drawings for the manufacture of high-speed circuitry of telemetering devices, missiles systems, automation controls, computers, communication equipment, radar, radio and television. Specifically, the work entails the design and drawing of schematic and wiring diagrams, and the detailing of the elements that make up the electro-mechanical package. These elements, in addition to the electrical circuitry, include the chassis and its enclosure, servo-mechanisms, and manually operated linkages.

Observations in this area involved four companies that employ a total of 316 designers and draftsmen.

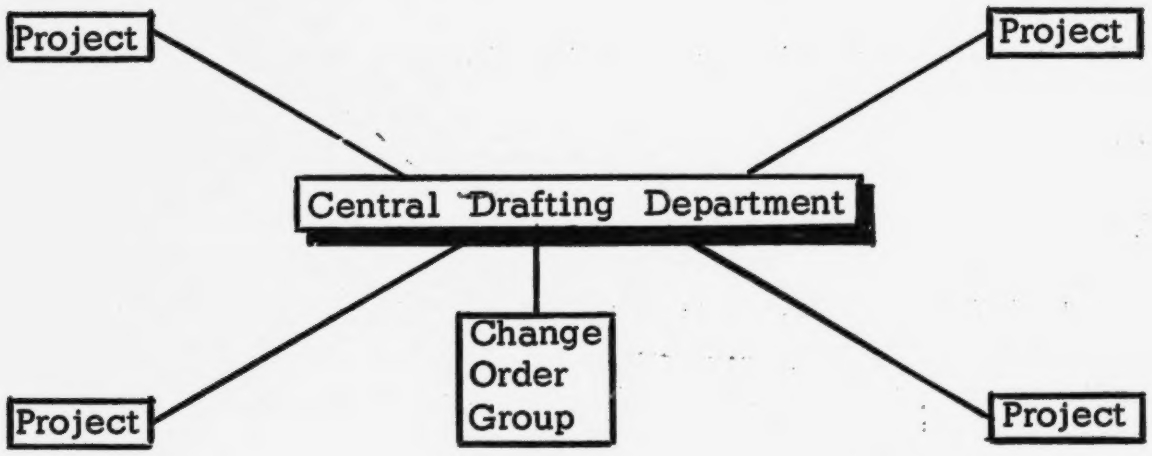
Company Code: A

Occupational Area Observed: Electro-Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 144

System of organization:

The system of organization for design and drafting activities for this company consists of a central service drafting group which serves as a nucleus for project or division drafting activity.



The central drafting department is basically divided into two groups - Electrical and Mechanical. An interchange of drafting personnel is maintained between central drafting and the various project drafting activities. Drafting personnel control is maintained by the head of the central drafting department.

Job classifications:

Classifications range from trainee to Chief Draftsman as follows: Trainee, Detailer, Layout Draftsman, Designer/Checker, Supervisor, Chief Draftsman.

Hiring practices:

Several sources for procurement of personnel are utilized. A Primary source is from job shop contacts. Other sources include routine personnel applications filed by experienced draftsmen. Students from high schools, trade schools and colleges are also employed. About six trainees are hired each year.

Training practices:

The training program involves about twelve weeks of instruction in areas of electrical and mechanical drafting including printed circuit work.

Promotion practices:

Personnel are given performance ratings every six months. Draftsmen progress through the grades of attainment in a series of 8 or 9 grade increments to the grade 8 senior designer. Normally a senior designer will need ten years minimum drafting experience with at least five years in design work. Pay range is approximately $95.00 per week for trainees to $160.00 per week for senior design level personnel.

Physical facilities:

Facilities are well lighted, clean, and air conditioned. Moderate crowding conditions were observed.

Furniture:

Standard wood type horizontally oriented five foot long tables are predominately used. Most tops are covered with grid line Laminene. In some cases Mylar is used as a backing surface. Stools with backs and cushions are used. Tables arranged facing front.

Equipment:

Twenty-four inch drafting machines are used. Most draftsmen work with one blade (horizontal) and utilize triangles for vertical lines. Table lamps are used.

Drawing Material:

Most of the drawings are done on vellum. Polyester film is used in printed circuit board layouts, and in some design layouts. The use of cloth was not observed.

Drafting room manual and other references:

A standard drafting room manual is used, the drafting room manual is based on Military Standards. Other references include books such as Machinery's Handbook, and a multitude of Military Standards as listed below. A change control manual is also used.

Standards:

Military Standards

3A — Format for production drawings

12B — Abbreviations for use on drawings

15-1A — Graphic symbols for electronic diagrams

16C — Electrical and electronic reference designations

29A — Requirements for drawing springs

100 — Engineering drawing practices

200 — Definition of terms for equipment division

681A — Identification coding and application of hook-up and lead wires

806B_____Graphic symbols for logic diagrams

1000_____Drawing, engineering and associated lists

Observed use of templates, appliques, lettering aids, and other time saving devices:

Symbol templates, circle guides. The majority of lettering is done freehand, however, stick-on lettering is used to a great extent. Preprinted stick-back printed circuit patterns are used to facilitate taping of printed circuit boards.

To what extent is ink used in this area?

Ink is not used to a great extent in this area. Occasionally ink will be used to produce schematic and block diagrams for technical publications.

Simplified drafting observed:

Working sketches are used frequently in preliminary schematic drawings. These are called "workhorse sketches" and are utilized until the design is finalized, then formal drawings are made from these sketches.

To what extent are computer devices used in this area:

To no significant extent except in calculation of initial design data used to operate two numerical controlled machines in the manufacturing area.

Method of handling changes and revisions:

A separate change order group, located near the vault area, is assigned the task of making necessary changes on drawings. In the change order area the technique of "mortising in" new views to replace obsolete views is used occasionally.

Method of checking drawings:

Generally speaking, checking is done by classified checkers. These checkers have several years of design experience.

System of storage of drawing data:

Microfilm.

Number of women employed in this occupational area:

Four.

Company Code: B

Occupational Area Observed: Electro-Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 75

System of organization:

Central design group which does all research and product designs and detailing. The department is divided into three groups 1) layout 2) detailing 3) checking. Work assignments are made on an availability and ability to perform the task basis.

Job classifications:

Design Engineer-15 years average experience

Senior Designer-10 years average experience

Designer-5 years average experience

Senior Draftsman-3 years average experience

Draftsman-1 year average experience or junior college graduate

Junior Draftsman-no prior experience required

Hiring practices:

After passing a three or six month probationary period, employees are assured of permanent employment. New employees are generally hired thru newspaper ads. Some recruiting is done at schools in the area.

Training practices:

On the job training. Some special courses are offered at the company. The company has a tuition refund plan which may be used by the personnel.

Promotion practices:

Policy of promoting from within the organization. Before new personnel are hired, a review of company personnel is made to see if they can be up-graded.

All personnel have merit reviews every six months. Upgrading and salary increases are considered at this time; also, deficiencies are called to the person's attention. Promotions are based on ability and initiative.

Physical facilities:

Air conditioned, adequate overhead lighting, insufficient reference table space, no crowding, easy access to reference material such as microfilm files, etc.

Furniture:

Auto shift and standard drafting tables. Mixture of five foot and six foot long tables.

Equipment:

Parallel straightedges plus some standard drafting machines. Electronic square root calculator, microfilm reader/printer, light table.

Drawing Material:

Predominately vellum but some work with polyester film phototracings. Mylar masters and Cronaflex reproductions used for all printed circuit work. Cut-n-strip Mylar used for some applications. Approximately 40% of drawings eventually are drawn on Mylar.

Drafting room manual and other references:

Engineering standard practice instructions which contain general drafting instructions, approved practices and procedures.

Materials standard practice instructions which contain all approved materials and processes.

Machinery's Handbook, gear manufactures handbook and other industry handbooks.

Standards:

Standard parts manual which lists commonly used parts. All military specifications which includes not only drafting requirements but also physical requirements.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Typing used where data or notes are extensive. Military standard electronic symbol templates, letter and circle templates, electric erasing machines, mechanical pencils. Lettering templates are used extensively.

To what extent is ink used in this area?

Ten percent ink.

Simplified drafting observed:

Springs, threads, gears, repetitive details such as row of holes, etc., variable or tabulated drawings, pictorial information shown on subassembly is not repeated on higher assembly.

To what extent are computer devices used in this area:

Presently considering using computers to prepare electrical schematics, also to make calculations involving gear trains and backlash information.

Method of handling changes and revisions:

Separate change group composed of Junior Draftsmen. This group is part of "on job" training for upgrading to higher classification.

Method of checking drawings:

A special group of checkers review all drawings.

System of storage of drawing data:

Microfilm is used to some degree, especially for in-plant ready reference of drawings. Most master drawings are reduced 50% to an autopositive intermediate and blue line prints are made from this. Original vellums are then stored in the vault.

Number of women employed in this occupational area:

Five.

Company Code: C

Occupational Area Observed: Electro-Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 94

System of organization:

This company has two drafting rooms within the facility. During peak work loads, job shop services are utilized.

Job classifications:

Three grades of draftsmen: Grade 7, 9, 11

Three grades of designers: Grade 5, 7, 9

Hiring practices:

Hiring is done through job shop contacts, newspaper ads and routine applications. Personnel are also recruited through local schools such as junior colleges.

Training practices:

On the job training is provided. This includes a series of formal presentations. The primary purpose of this instruction is for job orientation for new personnel, however, some presentations dealing with new techniques and procedures are attended by all drafting personnel.

Promotion practices:

Periodic evaluations are made of all personnel and promotions and pay raises are based on these reviews.

Physical facilities:

Facilities are air conditioned, clean and well lighted. Working conditions are crowded; however, additional facilities are being planned.

Furniture:

Combination reference desk/90 degree adjustable top tables (Hamilton, Auto-Tilt) are used throughout the drafting areas. Low posture chairs are used.

Equipment:

Counterbalanced drafting machines are on most of the boards. Parallel straightedges (with position locks) are on some boards.

Drawing Material:

Most of the work is done on polyester film; however, some mechanical design layout drawing is done on vellum.

Drafting room manual and other references:

A drafting room manual is used. Also, company engineering practices, materials handbooks, standard parts catalogs and references such as Machinery's Handbook are used.

Standards:

American Standards are used. Due to the nature of work, Military Standards are not used to a great extent.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Various types of templates are used, such as circle templates, symbol templates, spring templates, etc. Adhesive back typed lettering is used to some degree. Other lettering devices such as the chemical process Varityper produces letters which are used extensively in the make up of silk screens for labeling of printed wiring boards and control panels. Most of the lettering is done freehand. Lettering follows standard ASA practice.

To what extent is ink used in this area?

Very little work is done with ink.

Simplified drafting observed:

No unique simplified drafting practices observed. Simplification of threads, springs, gears and omission of repetitive detail was observed.

To what extent are computer devices used in this area:

This company is experimenting with automated (x-y plotter) drafting in the layout of printed circuit boards. Digital delineation is also being studied as a means of mass producing sheet metal parts. Computer memory banks are also being used by the designers to store data concerning parts availability. This data is recalled through remote units in a matter of seconds thereby saving the designer the time and trouble of looking up the parts in a catalog or parts book each time he has to verify the validity of a part.

The writer observed the x-y plotter in operation. The x-y plotter and automated circuit design is best described in the following write-up provided by the Lead Designer in Circuit Packaging of a prominent company:

> A method for making printed circuit artwork masters is a semiautomated procedure using an x-y co-ordinategraphy machine.
>
> The plotter, a programmed machine, is operated electrically by coordinates. It has a photographic head, which moves over a level table, on an x and y axis.

The head accommodates reticules, artwork patterns, and projects a beam of light through the reticules, photographically exposing film of glass on the plotter table. The plotter is capable of maintaining high precision accuracies consistently where a draftsman cannot.

The circuit packaging designer provides the plotter operator with a copy of the circuit card layout. The plotter operator will write the coordinates of the pad pattern on fortran sheets. The fortran information is next keypunched into punched cards. These cards are sequenced and used as the input, with a special program, to operate a computer. The output from the computer will be a punched paper tape, used by the plotter operator as his input. The computer, on command, will also provide numerical drilling tapes for a single of multiple drilling machine fixture.

The plotter operator, after exposing the pad pattern for a specified layout will develop the film or glass and furnish a positive film to the design draftsman. This positive film pad pattern will next be taped by the draftsman.

A. Semi-Automated Design

Todays printed circuit designs are becoming more oriented towards automatically designing the circuits and packaging the circuits by electronic machines. The manufacturing processes required to automatically drill, plate, etch and assemble the components to the circuit card are also being geared toward the electronic machine.

The first step toward full automation is to establish a basic pattern for the package required. At this time the designer must know not only the design parameters, but must be aware of the process capabilities in manufacturing and design automation. The designer should know how to communicate with these different areas of design and how to converse in their language.

The present semi-automated design consists of locating the pad patterns for a given design by coordinates onto clear photographic film. The pad pattern is established from the layout of the circuit. The draftsman then tapes the circuit runs.

There are some circuit designs which require a very high degree of pad and line location accuracy. When these types of designs are required, the design draftsman will establish a basic pad and line pattern based on a x-y type of design. The coordinates for such design will be used, along with the layout, to make accurate basic patterns. The x-y design technique uses the front artwork pattern with horizontal lines and the back artwork with vertical lines. The front and back pad patterns are identical. To connect the front and back sides together, plated-through holes are used. Additional pads are added at random whenever the design requires them. To disconnect lines on either side of the artwork, a cut is used. These cuts break the circuit runs and prevent short circuits.

The Plotter Operation constructs the basic artwork patterns in a negative state. The cut pattern made in a positive state is registered to its respective line pattern. A photographic positive is made which now shows the lines interrupted by the cuts. The additional pads and any additional .050" runs are photographed into a separate positive film. This pattern is next registered to the line cut pattern and a direct positive film is photographed. At this point we have the artwork pattern, accurate to within .001" and exactly the same as the designer's layout. The drawing numbers, monogram, underwrite symbol, and other markings are added to the artwork positives. Each side of the artwork is now ready for reduction to its proper size,-- the actual size. The actual size positive artwork is used by Manufacturing to fabricate the raw card.

Artwork revisions will be made on the coordinate tapes for the cut and pad patterns. The basic master patterns do not change. When a change is made, a repeat of the plotter and photographic process takes place. The changes that may occur on all other drawings will be incorporated by Circuit Packaging Drafting.

B. Automated Circuit Design and Documentation

Automated Circuit Design begins with computer programs, written specifically for a specified system. Logic engineers, circuit engineers, and the circuit packaging design draftsmen combine their information and present the design parameters to the programming group, who in turn write the information into computer language.

The computer language used will be typed as an x-y linear coordinate method. This means that all electric connection lines for a given circuit design will be identified by coordinates read from a fixed point. The computer designed circuit will appear in print out form from the printer output machine. Numerical numbers, arranged to illustrate a circuit layout, will replace the design draftsman's layout. The coordinates for each circuit design will be recorded and punched into paper tapes or stored on magnetic tape or punched cards. Other memory devices may be used to store the final circuit design.

The print out design will be checked automatically by the computer to assure that all design limits and electrical specifications have been followed. After the design and checking have been completed, the paper tape will be sent to the Plotter Operation to be used as the input information on the Gerber drafting machine.

The Gerber is a high accuracy plotting system designed by the Gerber Scientific Instrument Company, out of Hartford, Connecticut. This system operates on a digital basis and is capable of accurately positioning x-y coordinate data from punched paper tape or manual keyboard. A light source, forced through predetermined reticules, mounted in a moving light head exposes photographic material placed on the plotter table. The pattern created will be the artwork master design by the computer. The size of the artwork made on the Gerber is actual.

The Gerber will also construct the assembly drawings by using reticules that represent the various components. Elementary diagrams and parts lists will be automatically made on computers and other electronic devices. The drafting group will check and provide the proper formats for all drawings made by the computer and Gerber plotter.

The most common question asked at this time is, "How does Automated Design affect the draftsman?"

The draftsman is by no means eliminated. His job becomes a more technical one, in that he now must be aware of what the computer cannot do. A computer program is limited as to what it can do, mainly because of the information used during the program construction. There are so many variables in circuit designs that all the factors are not covered. Therefore, the computer programmed design incurs a "can't connect" condition. Design automation assists the design groups in attaining the goals they seek.

By: Kenneth Aylesworth
(printed by permission)

Method of handling changes and revisions:

Changes are made within the major drafting areas, not in a special group.

System of storage for drawing data:

Generally, microfilm.

Method of checking drawings:

No personnel are designated specifically as checkers. For the most part designers do their own checking.

Number of women employed in this occupational area:

Seven.

Company Code: D

Occupational Area Observed: Electro-Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 3

System of organization:

Central drafting room system.

Job classifications:

Chief Draftsman, General Draftsman, Trainee Draftsman.

Hiring practices:

Hiring is usually performed through personal contact within the company.

Training practices:

On-the-job informal training is used.

Promotion practices:

Merit review every six months determines promotions. Salary increase is approximately five percent of present salary.

Physical facilities:

Facilities are extremely modern, well lighted, spacious, and clean.

Furniture:

Standard five, six, and seven foot horizontally oriented tables are used. Stools have backs and are upholstered.

Equipment:

Parallel straightedges are used exclusively. Adjustable table lamps are used. Electric erasers are used. A Varityper is used to type notes on adhesive-back materials.

Drawing Material:

The majority of drawing is done on vellum. Some special jobs are drawn on polyester film.

Drafting room manual and other references:

A standard drafting room manual is being formulated. This is to be based on the principles of Military Standards. Other references such as Machinery's Handbook are used.

Standards:

Military Standard 100 and 15-1A are used extensively.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Almost all lettering is freehand; however, on special jobs lettering guides, rub on letters and adhesive-back letters are used.

To what extent is ink used in this area?

Ink is used to a significant degree on illustrations, charts, forms, meter faces, and ad sheets.

Simplified drafting observed:

Functional drafting such as omission of unnecessary hidden lines, omission of repetitive detail, etc. was observed.

To what extent are computer devices used in this area:

Progress is being made toward adoption of computer programming to facilitate control of part numbers, control lists, and other paper work.

Method of handling changes and revisions:

Changes are handled by general drafting personnel.

System of storage of drawing data:

Originals are filed. The company is considering the microfilm system.

Method of checking drawings:

The Chief Draftsman checks drawings.

Number of women employed in this occupational area:

One.

SUMMARY OF PRACTICES OBSERVED IN ELECTRO-MECHANICAL DESIGN AND DRAFTING

Electro-mechanical design and drafting activities in Maricopa county involve a large number of designers and draftsmen employed in the county. At the present time one major company has an outstanding requisition for twenty designers and draftsmen.

The system of drafting room organization varies according to the structure of each company. Generally, the organization can be classified as the project approach or the central drafting room approach. In at least one major company the central drafting room concept is carried out in conjunction with the project approach.

Job classifications vary from company to company. All of the companies observed, hire a limited number of personnel who have little or no previous experience. Hiring is generally done through newspaper ads, local schools and contacts within the company. Several of the companies provide some formal training. All of the companies provide informal on-the-job training. All companies use the six month rating procedure as a basis for promotions.

All physical facilities are air conditioned, clean, and adequately lighted. In many facilities the overhead lighting is supplemented by adjustable table lamps. Most design and drafting facilities are crowded. Drafting tables are of two basic styles - - standard tables (horizontally oriented) and the upright adjustable tables (Hamilton Auto-Tilt with reference desk). The upright variety is used by approximately one third of the designers and draftsmen observed. Drafting machines are used by approximately two thirds of the personnel observed. The remainder of the personnel use parallel straightedges. Not a single T-square was observed. Mechanical calculators are used in most drafting rooms. One facility is using an electronic calculator. Drawing material used is predominantly vellum; however, polyester film is being used in many cases. All printed circuit artwork is done on film.

All companies have a drafting room manual and a multitude of other references available. Most of the drafting room manuals are based on Military Standards. With few exceptions Military Standards provide the rules for the generation of drawings in electro-mechanical drafting throughout the companies observed.

Freehand lettering is used on the majority of drawings. Vertical commerical Gothic style lettering is predominant. Lettering and linework techniques follow Military Standards and the American Standards Association rules. The use of microfilm documentation has placed particular emphasis on legibility of letters and lines. Lettering typed on adhesive back transparent material and adhered to vellum is gaining popularity. Lettering templates to facilitate uniformity of letters is used extensively by one major company. Symbol templates, circle guides, and standard parts templates are used extensively throughout the companies. Electric erasers and mechanical pencils are standard equipment. Very little ink work was observed in the electro-mechanical drafting areas.

Many of the true simplified drafting techniques (omission of arrowheads, etc.) are not used by the companies. Simplification of threads, springs, gears and omission of unnecessary views and repetitive details is standard practice in most companies. The term "functional drafting" is becoming popular.

At least two companies in Maricopa County are experimenting with the use of automated techniques in the generation of drawings. This technique is particularly adaptable to precision design and layout for printed wiring circuits. Schematic drawings by automation are also under study by several companies.

Drawing revisions are usually made by draftsmen especially assigned to perform this task.

Most companies are changing to the microfilm system for storage of drawing data; however, this system has its drawbacks and is not used one hundred percent by most companies.

There is controversy as to what method of checking of design and drawing data is desirable in the electro-mechanical areas. Some companies have personnel classified as checkers who review all design and drafting documents. Other companies leave the responsibility of checking to the designers involved. Classified checkers are favored by most of the draftsmen interviewed. The classified checker is viewed as a "necessary evil". His job is to systematically check a drawing not only for design functionability but for drawing technique and format as well.

Women account for approximately five percent of the personnel employed in the electro-mechanical design and drafting occupations observed.

Job opportunities for persons with the desire and ability to perform in the electro-mechanical design and drafting areas appears to be unlimited.

CHAPTER III

MECHANICAL DESIGN AND DRAFTING

The field of mechanical design and drafting covers a wide variety of products and employs a large number of personnel in Maricopa County. Mechanical design and drafting may involve design/drafting for a kitchen utensil, a simple hand tool, propulsion machinery of a jet aircraft, a child's toy, hydraulic turbines, seat ejection equipment for aircraft, or missile transporters. The work may involve items that have no moving parts, but may need to be designed for size, shape, and mechanical strength, as, for example, truck bodies. Or the work may be concerned with the design of an intricate mechanism with many simultaneous, co-ordinated motions, such as gears and gear applications, gas turbines, or gyros.

The work is generally divided into two categories - - design and detailing. Designers normally prepare drawings of complex component assemblies and parts which require maximum drafting knowledge and direct the preparation of detailed drawings. Designers are involved in the calculation and selection of fits, tolerances, material factors, and the writing of specifications. Detailers generally make detail drawings of parts or routine subassemblies incorporating all the necessary information on dimensions, materials, specifications, notes, which will be required to produce the part; and preparation of all other related engineering forms and data which become associated with drawings in the manufacture of products.

Observations in this area involved four companies which employ a total of 247 designers and draftsmen.

Company Code: E

Occupational Area observed: Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 125

System of organization:

The project system of organization is utilized. A project will involve conceptual design specialists as well as product layout designers, design draftsmen, detail draftsmen, and checkers. With the exception of conceptual studies, the projects are carried on in one large room with engineers, designers, and draftsmen working in close proximity.

Job classifications:

Job classifications in the design and drafting areas are as follows: Design Specialist, Senior Design Engineer, Design Engineer, Associate Design Engineer, Design Draftsman"A", Design Draftsman"B", Detail Draftsman"A", Detail Draftsman"B".

Hiring practices:

At the present time the company is hiring many junior college graduates. Other sources include job shop contacts and through routine employment channels such as newspaper ads, etc.

Training practices:

No formal curriculum as such; however, the company maintains a separate change order group headed by a lead draftsman with the assistance of a checker. Most new draftsmen with no experience are usually placed in this group for a period of time. This experience is in effect a training program.

Promotion practices:

Promotion practices were not investigated to a great extent. Periodic evaluation of design and drafting personnel is made and promotion is based on these reviews. Salary for an associate design engineer, for example, ranges from $534 to $805 monthly.

Physical facilities:

Facilities are well lighted and air conditioned. Working conditions are crowded.

Furniture:

Standard drafting tables (horizontally oriented) are used. Stools are equipped with backs.

Equipment:

Twenty-four inch drafting machines used with both horizontal and vertical blades were observed. Electric erasers are used extensively. Adjustable table lamps are used.

Drawing Material:

The majority of drawing work done at this company is on polyester film. Some initial design rought layouts are drawn on vellum. Casting drawings are penciled on cloth.

Drafting room manual and other references:

A company drafting room manual is maintained. The detail drafting practices for the manual are based on Military Standard 100. Other references include a multitude of parts catalogs, materials handbooks, and Machinery's Handbook.

Standards:

Military Standards are used extensively by this company. In addition the company uses its own engineering and manufacturing standards.

Observed use of templates, appliques, lettering aids, and other time saving devices:

The company uses preprinted title blocks. In some cases the standard notes are applied to the drawings with type on adhesive-back material. The electronic drafting group uses type on lettering extensively. Circle guides are standard equipment.

To what extent is ink used in this area?

To no significant degree.

Simplified drafting observed:

Cross hatching on sectioned views is at least 90% eliminated. Simplified threads, springs, gears, and elimination of repetitive details were also noted.

To what extent are computer devices used in this area:

Computers are used in the conceptual design stage to cut calculation time by at least two-thirds. For example, the calculations that normally require one man year can now be done in a few minutes by the computer; however, it may take three to four months to program a design study for the computer.

Method of handling changes and revisions:

A separate group is set up for this purpose.

System of storage for drawing data:

Microfilm.

Method of checking drawings:

Personnel designated specifically as checkers review all design and drafting work.

Number of women employed in this occupational area:

One.

Detail drafting practices:

Detail drafting practices follow Military Standard 100 for the most part. Military Standard 100 (Engineering Drawing Practices) lays the ground rules for drawings that are prepared to be used in the production of products used by the Federal Government. It would be well for drafting teachers to have at least one Military Standard 100 available for reference.

A discussion with a checker in this company provided the following comments concerning detail drafting practices that should be taught to the student draftsman:

1. Accurate drawings
2. Correct placement of views
3. Neat lettering
4. Contrast of lines

He also pointed out the problem that many young draftsmen do not show enough concern about functionability of assembled parts. Parts must be designed and drawn to fit at assembly. "Stacking" and "tolerencing" are basic to any machine drawing course and should be emphasized from the first of the course.

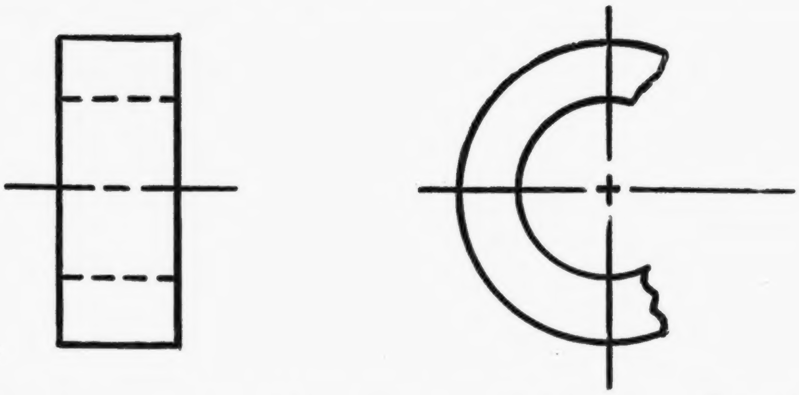
Notes and specification are another area where beginners are weak. Most companies are attempting to standardize their notes. The concept of "end-product" notes is improtant. In "end-product" notation the draftsman is not concerned with the specification of the various operations that must be performed on the part. Intermediate details of the various operations are the problems of personnel other than the draftsman; however, the draftsman is concerned with the functionability of any note that he writes. For example, when noting the size of a hole use the note one half inch DIA rather than one half inch DRILL. This leaves the manufacturing engineer some options as to how this hole is to be produced. Good design will dictate that the hole is to be in a location that is accessible.

The observer noted several detail drafting practices that are not commonly published in textbooks. These practices are illustrated on the following pages.

Detail drafting practices: (continued)

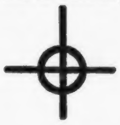
1. Section lines (crosshatching) are eliminated on the majority of assembly and detail drawings. This is reportedly done to save time.

2. Half views are extended slightly beyond the center line of symmetry and terminate with a freehand break line. (This is from Mil. Std. 100)

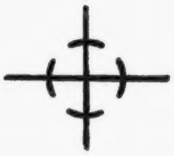


3. Ink lines have the same proportion as pencil lines. (This is implied in Mil. Std. 100)

4. Very short center lines may be unbroken if there is no confusion with other lines.



5. Hidden line technique for small circles is:



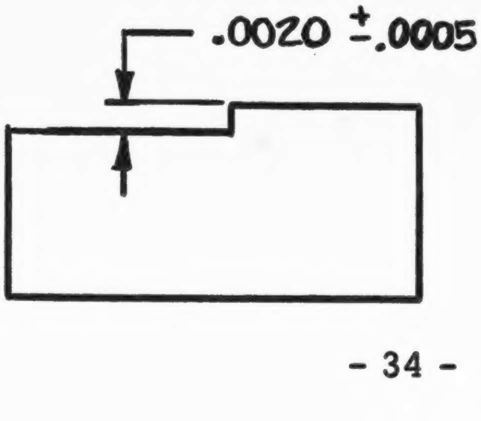
6. Center lines cross without voids.

7. The practice of this company is to designate all dimensions in decimals.

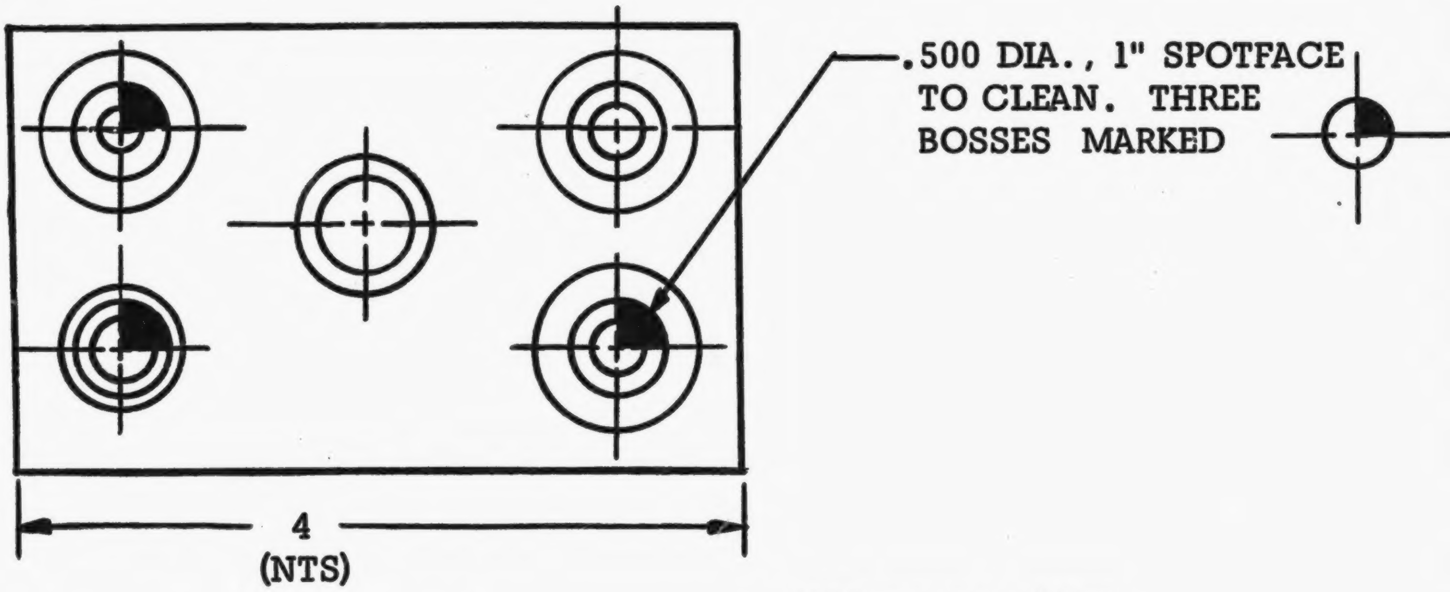
8. All dimensions are unidirectional.

9. Minimum size of letters after reduction shall not be less than 3/64".

10. Intentional exaggeration of a view is sometimes shown to show an important feature. (From Mil. Std. 100)



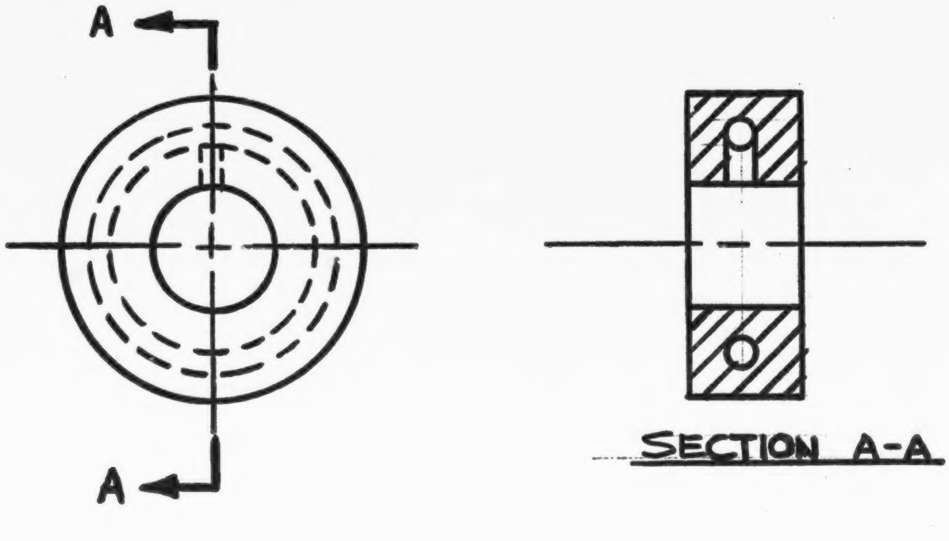
11. Operations are sometimes shown with special attention getting symbols.


.500 DIA., 1" SPOTFACE TO CLEAN. THREE BOSSES MARKED
4
(NTS)

12.

NTS means : "Not True Scale"

13. Cutting plane lines are not usually carried completely through the object, except for offset sections.


A
A
SECTION A-A

Company Code: F

Occupational Area Observed: Mechanical Drafting (Job Shop)
(Nature of work)

Number of employees in this area: 15

System of organization:

Work is assigned by the chief draftsman to draftsmen who are more or less specialists in certain phases of drawings. This is a job shop that subcontracts work from major companies; therefore, the drawings are varied according to the current needs of the major companies.

Job classifications:

Trainees, Detailers, Designers, Checkers.

Hiring practices:

Routine employment channels such as newspaper ads, regular application forms, and local schools.

Training practices:

Some on-the-job training is given. Many employees have attended evening drafting classes at Phoenix College.

Promotion practices:

Ability is the prime factor in promotions. Pay rates are normally higher than those paid by major firms; however, during periods when the demand for drafting is low, job security may not be present in a job shop situation.

Physical facilities:

Facilities are air conditioned and well lighted.

Furniture:

Standard five foot horizontal drafting tables are used. Adjustable table lamps are used.

Equipment:

Drafting machines (24 inch) and parallel straightedges are common. Electric erasers are used.

Drawing Material:

Vellum is used to a great extent. Polyester film was being used on several jobs.

Drafting room manual and other references:

Due to the nature of job shop work it becomes necessary for draftsmen to become familiar with the drafting room manuals of several companies.

Standards:

Military Standards are used on work that is done for companies that must meet governmental standards.

Observed use of templates, appliques, lettering aids, and other time saving devices:

A number of templates were observed in use. These included circle templates, symbol templates, spring templates, nuts and bolts templates, lettering templates, and various others. Leroy lettering instruments were in use at several tables.

To what extent is ink used in this Area?

This company is engaged in telephone exchange documentation and much of this work is done with ink on polyester film.

Simplified drafting observed:

Simplified drafting was not being used to a significant degree.

To what extent are computer devices used in this area:

Computer devices are not used to a significant degree.

Method of handling changes and revisions:

Change orders are handled within the overall drafting effort. No separate group is set up for this purpose.

Number of women employed in this occupational area:

Two.

Detail drafting practices:

One unique practice that is used in order to facilitate changes on a drawing involves drawing the basic features of a layout on the front side of polyester film with a colored pencil. The film is then flipped over and the basic features are inked on the back side of the sheet. The sheet is then flipped to the original position and the details are added. When the details of a drawing are changed, they can be washed from the front side of the sheet without affecting the basic layout. This practice is particularly useful in telephone exchange documentation where the basic geographic features remain static and the telephone data is in constant change.

Company Code: G

Occupational Area Observed: Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 7

System of organization:

Central drafting room system of organization is utilized. Work is assigned to the various designers and draftsmen according to their availability and competence.

Job classifications:

Supervisor, Checker, Design Draftsman, Draftsman, Junior Draftsman.

Hiring practices:

Turn over rate is low. New employees are recruited through routine employment channels such as existing applications and newspaper ads.

Training practices:

On-the-job informal training is used.

Promotion practices:

Periodic review of efficiency is the basis for promotion. Employees are rated twice during the first year of employment and yearly thereafter. Salary increases are usually about five percent of present salary.

Physical facilities:

Facilities are exceptionally modern. Overhead lighting is supplemented by north light provided by large windows in the drafting area.

Furniture:

Six foot standard horizontally oriented drawing tables are used. Tables are equipped with desk style drawers.

Equipment:

Three foot drafting machines are standard equipment. Electric erasers are used by each draftsman.

Drawing Material:

Drawings are on vellum, except heavy use drawings which are on Mylar. Cloth is not used. Some drawings are reproduced on reproducible Mylar to facilitate ease of change.

Drafting room manual and other references:

A standard drafting room manual is used. Miliatry Standard 100 is the basis for this manual. Other engineering, materials, and handbooks are readily available.

Standards:

Military Standards are used to guide most of the drawing activity.

Observed use of templates, appliques, lettering aids, and other time saving devices:

The majority of lettering is done freehand; however, some Leroy lettering templates are also used on occasion. "Scissors Drafting" was observed. Standard part templates are used. Many types of plastic templates are used.

To what extent is ink used in this area?

Ink is not used to a great extent. Illustrations and charts are usually inked.

Simplified drafting observed:

Simplified drafting, except for techniques to avoid repetitive drawing of similiar details, was not observed. "Scissor Drafting" (see above) might be classified as a form of simplified drafting.

To what extent are computer devices used in this area:

Data provided by computers is often used in initial design work. The company has a remote computer outlet installed near the design area.

Method of handling changes and revisions:

Changes are made by available design and drafting personnel.

Number of women employed in this occupational area:

None.

Method of checking drawings:

A permanent checker has the responsibility of reviewing all design and drafting work.

System of storage of drawings:

Diazo reproduction equipment is used to copy drawings. Masters are stored vertically in a fire proof cabinet. Some jobs require microfilming. Microfilming is performed by an outside source.

Company Code: H

Occupational Area Observed: Mechanical Design and Drafting
(Nature of work)

Number of employees in this area: 100

System of organization:

The design and drafting activities are divided into departments or groups. Each department has a department head. Draftsmen, designers and engineers work in close proximity. In many cases the degree engineers perform design drawing work.

Job classifications:

Engineering Specialist Designer, Senior Designer, Designer, Designer Draftsman, Senior Draftsman, Junior Draftsman.

Hiring practices:

Personnel are procured through newspaper ads placed locally and out of state, job shop contacts, and from applications on file.

Training practices:

Informal on-the-job training is provided.

Promotion practices:

Personnel are evaluated every six months. Consistent high ratings during a period of two or three evaluations will usually result in a promotion. This is contingent upon the present position of the individual.

Physical facilities:

Facilities are air conditioned, clean and well lighted. Working conditions are moderately crowded.

Furniture:

Standard eight foot wood drafting tables are used. Several tables are equipped with adjustable table lamps, bookcases are used for storage of reference material.

Equipment:

Conventional type drafting machines are used by most of the designers and draftsmen. A few parallel straightedges are used.

Drawing Material:

The majority of drawing is done on vellum. Some polyester film is used for printed circuit layouts. Some projects are using polyester film exclusively for drawing material.

Drafting room manual and other references:

The company publishes a drafting room manual, design manual, standard parts manual, process manual, material specifications and other handbooks and manuals. Subcontract work for other companies is subject to the drafting requirements of that company. In addition, all draftsmen have ready access to a multitude of technical publications that are provided by professional organizations and vendors.

Standards:

On many projects the design and drafting efforts must conform to the various military standards.

Observed use of templates, appliques, lettering aids, and other time saving devices:

The majority of lettering is done freehand. A few lettering templates were observed. Various symbol templates were observed along with numerous standard parts templates.

To what extent is ink used in this area?

The use of ink was not observed.

Simplified drafting observed:

The use of simplified drafting was not observed.

To what extent are computer devices used in this area:

Computer devices are used in the computation of some initial design data.

Method of handling changes and revisions:

Some departments use a separate group of draftsmen to make changes. Other departments use general draftsmen to make changes.

System of storage of drawings:

At the present time the originals are filed for future reference and changes. The company has recently invested in microfilm equipment that will be used to set up a system of microfilm storage of drawing data.

Method of checking drawings:

No official group is set up for checking purposes. Checking is done within each department. A person other than the originator of a drawing performs the checking on that drawing.

Number of women employed in this occupational area:

One.

SUMMARY OF PRACTICES OBSERVED IN MECHANICAL DESIGN AND DRAFTING

Mechanical design and drafting activities account for a large portion of the designers and draftsmen employed in Maricopa County. Interviews indicate that at the present time the demand for competent mechanical designers and draftsmen exceeds the supply.

The larger companies observed favor the project/group approach to drafting room organization, while the smaller companies, by necessity, use the central drafting room approach. In most of the companies observed the engineers, designers, and draftsmen work in close proximity.

Job classifications vary; however, most companies have at least three grades of draftsmen. Most companies prefer experienced personnel, but will hire persons with very little formal training or experience if the individual shows potential.

None of the companies observed have formal training programs. One major company has a change order section where most of the inexperienced personnel work and learn company drafting practices. Periodic review of efficiency is the basis for promotion.

All facilities are air conditioned, clean, and adequately lighted. Several companies have crowded working conditions. Most of the mechanical designers and draftsmen use standard drafting machines. A few parallel straightedges are used. Not a single T-square was observed. Standard five, six, and eight foot horizontally oriented drafting tables are used in the companies observed.

The use of polyester film was found to be relatively high in the mechanical design and drafting areas. It is estimated that in the companies observed, at least forty percent of the drawing material is film. Vellum is used to a great extent. Cloth is used for some casting drawings.

Most companies have standard drafting room manuals. These manuals are generally based on Military Standards.

Most of the lettering is done freehand. Lettering and linework requirements are essentially the same as those in electro-mechanical drafting. Several companies use pre-printed adhesive back standard notes. Typed lettering is used to a very limited degree. Various symbol templates were observed along with numerous standard parts templates. Circle guides are standard equipment.

Ink is not widely used in mechanical design and drafting. Omission of section lines as a means of simplifying drawings is used extensively by one major company. Other simplified techniques such as omission of similiar details was observed throughout the companies. "Scissors" drafting was observed in one company.

The use of computer devices for calculation of initial design data and for the control of machining operations is common in mechanical design and drafting. At this time automated drafting techniques are not used in the companies observed. Also, no indication was given that automated drafting techniques will be initiated in the near future.

In most of the mechanical design and drafting areas observed, the drawings are checked by classified full time checkers. Drawing revisions are usually made by draftsmen especially assigned to perform this task. One major company has a change order group which is physically separated from other drafting activities.

Most companies are changing to the microfilm system for the storage of drawing data.

Women account for less than two percent of the personnel employed in the mechanical design and drafting occupations observed.

Several unique detail drafting practices were observed and reported.

CHAPTER IV

CIVIL DRAFTING

Civil drafting differs from other areas of drafting in that the general raw data used for drawing is normally gathered by land surveying. The primary concern of civil drafting, therefore, is with drawing and plotting forms that are in and on the ground rather than with the structural and mechanical feature of buildings and machinery.

Civil draftsmen make up a sizable group in Maricopa County and are found in such places as municipal government offices, state and federal government offices, public utility companies, and civil engineering or consulting firm offices.

Observations in this area involved four companies which employ a total of 200 designers and draftsmen.

Company Code: I

Occupational Area Observed: Civil Drafting (and related areas)
(Nature of work)

Number of employees in this area: 102

System of organization:

The squad system of organization is used. A project is assigned to a squad. A squad usually consists of from six to eighteen men and is directed by a squad leader.

Job classifications:

Junior Draftsman, Draftsman 1,2, and Senior Draftsman; Designer 1,2, and Senior Designer.

Hiring practices:

Turn-over rate is not high. When a vacancy exists, experienced personnel are sought. Some personnel are recruited from highway departments in other states. One department head expressed a keen interest in local junior college graduates as a source of personnel.

Training practices:

No formal training program for draftsmen.

Promotion practices:

Promotions are based on periodic reviews and merit exams.

Physical facilities:

Facilities are air conditioned, well lighted, clean, and spacious.

Furniture:

Standard five foot and six foot horizontally oriented drafting tables.

Equipment:

Parallel straightedges and drafting machines. Adjustable table lamps are used. Electric erasers are standard equipment.

Drawing Material:

Predominately cloth.

Drafting room manual and other references:

Drafting standards are published by each division.

Standards:

Federal specifications are used as standards for interstate roads.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Circle templates and many types of symbol templates are used (metal pipe, bin type retaining wall, multi-plate pipe arches, etc.). Blu-zip is used for back-ground tinting. Some stick-on symbols are used. Some Leroy lettering is performed.

To what extent is ink used in this area?

Ink is used on the majority of drawings.

Simplified drafting observed:

Simplified drafting is not used to a significant degree.

To what extent are computer devices used in this area:

Computer equipment is used in initial design calculations, for example, plotting of roadway cross sections and earth movement data.

Method of handling changes and revisions:

Changes are usually handled by the squads that originated the drawings.

Number of women employed in this occupational area:

Two.

Detail drafting practices:

1. Compass adapter used with Leroy technical fountain pen was observed in some areas. This enables the draftsman to draw ink curves and circles using the same line consistency as used for straight lines.
2. Drops of glue adhered to the bottom of triangles to raise the working edge of triangles above the surface of the linen, was used by several draftsmen. This practice aids in preventing ink-run mistakes.

Company Code: J

Occupational Area Observed: Civil Drafting
(Nature of work)

Number of employees in this area: 60

System of organization:

Group system of organization. Each group more or less specializes in a certain function of drafting.

Job classifications:

Engineering Aide 1,2,3.

Hiring practices:

Personnel are selected through an examination procedure. Local schools are a common source of personnel.

Training practices:

On-the-job training.

Promotion practices:

Periodic evaluations and merit examinations determine promotions.

Physical facilities:

Air conditioned, well lighted, clean, spacious.

Furniture:

Standard five foot horizontal drafting tables are used.

Equipment:

Drafting machines are used. Electric erasers are standard equipment. Adjustable table lamps are used.

Drawing Material:

Most of the drawings are on vellum; however, polyester film and linen is used to some extent.

Drafting room manual and other references:

Standard textbooks are used for reference.

Standards:

Engineering standards are used in most divisions.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Chart-Pak tape is used frequently. Leroy lettering is supplemented by press on letters. Sepia masters for basic layout data are utilized.

To what extent is ink used in this area?

Ink is used on perhaps 40% of the work generated by this facility.

Simplified drafting observed:

No simplified practices observed.

To what extent are computer devices used in this area:

Computer devices are not used to a significant extent.

Method of handling changes and revisions:

Changes are made within the area that generated the drawing. No separate change groups.

System of storage for drawing data:

Microfilm is being phased into use.

Method of checking drawings:

Lead draftsmen do most of the checking.

Number of women employed in this occupational area:

Three

Company Code: K

Occupational Area Observed: Civil Drafting
(Nature of work)

Number of employees in this area: 16

System of organization:

The squad system of organization is used. Work is assigned on the basis of ability to perform the task.

Job classifications:

Lead Draftsman, Draftsman, Junior Draftsman.

Hiring practices:

Most of the people hired into this facility are experienced draftsmen; however, a few college students are hired during the summer months.

Training practices:

On-the-job training.

Promotion practices:

Periodic reviews determine promotions.

Physical facilities:

Air conditioned, well lighted, clean and spacious.

Furniture:

Standard six foot drafting tables.

Equipment:

Twenty-four inch drafting machines are used. Electric erasers are standard equipment. Standard flat files are used.

Drawing Material:

Most of the work is done on cloth.

Drafting room manual and other references:

Standard drafting room manual is used.

Standards:

Federal standards are used on federal projects.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Various templates are used extensively. Some lettering is done with a Leroy set; however, most lettering is done freehand with ink.

To what extent is ink used in this area?

Practically all work is done in ink. Some bridge work is done with pencil on vellum.

Simplified drafting observed:

Simplified drafting was not observed.

To what extent are computer devices used in this area:

Computers are used in plotting cross sections and in calculation of earth movement data.

Method of handling changes and revisions:

Changes are handled within the squads.

Method of checking drawings:

Squad leaders do most of the checking.

Number of women employed in this occupational area:

One.

Company Code: L

Occupational Area Observed: Civil Drafting (and related areas)
(Nature of work)

Number of employees in this area: 22

System of organization:

Central drafting room approach is used. Work is assigned according to ability of draftsmen.

Job classifications:

Drafting Supervisor, Senior Draftsman, General Draftsman A,B,C, Draftsman A,B,C, Junior Draftsman A,B,C, (C=lowest grade.)

Hiring practices:

Personnel are usually procured from within the plant. Job openings are let on a bid basis. If in-plant personnel do not bid for positions, then existing applications from employment offices are reviewed.

Training practices:

Periodic formal courses are given in various phases of drafting; however, informal on-the-job training is performed throughout the year.

Promotion practices:

Periodic review (six months) determines promotions. Examples of salaries: Junior Draftsman "C"____ $425.00 per month, Draftsman "C" ____ $459.00 per month, General Draftsman "C" ____ $494.00 per month, Senior Draftsman ____ $530.00 per month (salaries based on a 40 hour work week.)

Physical facilities:

Facilities are air conditioned, clean, and well lighted. Crowding conditions do exist. This department will be moving to new facilities in the near future.

Furniture:

Hamilton Auto Shift tables are used throughout the area. Stools are upholstered. A large light table is available.

Equipment:

Parallel straightedges are used on most boards. These straightedges have position locking devices. Several track type drafting machines are in use. Electric erasers are standard equipment. A Varityper is available. A calculator is available.

Drawing Material:

A variety of drawing material is used, however most work is on vellum and cloth. Mylar reproducibles are used extensively to facilitate changes.

Drafting room manual and other references:

A standard drafting room manual is being formulated.

Standards:

Drafting practices are based primarily on the American Standards Association documents.

Observed use of templates, appliques, lettering aids, and other time saving devices:

About 90% of lettering is done freehand (inclined caps) adhesive back reproducible notes, formats, and standard parts are used extensively. Press on letters are used frequently. A variety of templates are used. Leroy inking equipment is used to standardize lettering on many drawings.

To what extent is ink used in this area?

Ink is used extensively in the mapping section. Colored ink is used occasionally.

Simplified drafting observed:

Functional drafting such as omission of hidden lines unless needed for clarity, and elimination of unnecessary views and noting of repetitive details were observed.

To what extent are computer devices used in this area:

Computer devices are used to keep an up-to-date record of the progress of each drawing.

Method of handling changes and revisions:

Minor corrections are done by the originator. Major revisions are treated as new drawing jobs.

Method of checking drawings:

The drafting room organization is being arranged to provide for a permanent checker.

System of Storage of Drawings:

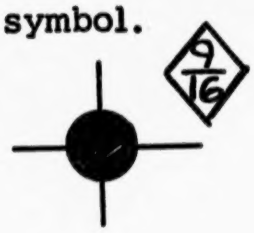
Master tracings are filed; however, a set of microfilm plates are kept for security reasons. The company is changing the entire storage system to microfilm.

Number of women employed in this occupational area:

One.

Unique detail drafting practices:

1. The company is presently engaged in developing a system of photo drawings.
2. On some structural drawings the holes are being shaded in and the size of the hole is given within a nearby symbol.



3. Orange carbon paper is used as a backing sheet on some drawings. This is used to obtain line reproducibility.

SUMMARY OF PRACTICES OBSERVED IN CIVIL DRAFTING

The growth of municipalities, county road systems, state and federal road systems, and the ever increasing demand for water in Maricopa County has created a need for a significant number of civil draftsmen in the County.

In observing civil drafting activities it was found that the squad system of drafting room organization is used by several companies. Where great diversity of work is involved, either the group system or the central drafting room approach is used. Job classifications are varied, ranging from three grades of draftsmen to nine grades of draftsmen. No set pattern of hiring practice is established. Some companies hire only highly experienced personnel while others will hire youngsters directly from high school.

One company performs limited formal training; however, most companies use "occupational osomosis" for training.

Periodic review is used as a basis for promotions. Some companies supplement reviews with merit exams.

All facilities are air conditioned, clean, and well lighted. Three of the four companies observed have relatively spacious working conditions.

Most of the companies are using standard horizontally oriented drafting tables. One company uses Hamilton Auto Shift tables throughout the area. Drafting machines lead slightly in usage over the parallel straightedge in civil drafting. Not a single T-square was observed. The track type drafting machine is particularly favored by draftsmen.

One of the major differences between civil drafting techniques and techniques used in other areas of drafting is the extensive use of ink in civil drafting. Most drawings generated for road construction are inked on cloth. Polyester film intermediates are used in several companies. The majority of lettering in civil drafting is done freehand. Mechanical lettering is generally used on titles, headings, etc. Typed lettering and transfer lettering is widely used. Use of adhesive shading material was observed in several firms. Unique simplified drafting practices were not observed.

Computer devices are used to a limited degree in computing initial design data and in drawing control.

Checking is usually done by the squad leader or lead draftsman. Changes are made within the squad or group.

Microfilm is being phased into use in two of the four companies observed.

Women account for approximately three percent of the personnel employed in the civil drafting occupations observed.

CHAPTER V

STRUCTURAL DRAFTING

Structural drafting deals with the development of designs and details for buildings, bridges, dams, docks, ships, and other structures which must withstand the stresses imposed by external forces as well as the stresses inherent from the weight of the object itself. For the most part, structures are made of steel, reinforced concrete, timber, or a combination of these materials, although sometimes stone, brick and glass blocks are also used as loadbearing structural components.

Structural draftsmen may be employed by architects, contractors, steel fabricators, shipbuilders, utility companies and mine operators.

Observations seem to indicate that structural drafting involves a relatively small number of draftsmen in Maricopa County; however, job opportunities in this occupational area presently exist for qualified personnel.

Observations in this area involved three companies which employ a total of 23 designers and draftsmen.

Company Code: LL

Occupational Area Observed: Structural Drafting (and related areas)
(Nature of work)

Number of employees in this area: 16

System of organization:

The central drafting room approach is used; however, due to present facility limitations, general drafting personnel are located in various sections of the plant.

Job classifications:

Drafting Supervisor, Senior Draftsman, General Draftsman A,B,C, Draftsman A,B,C, Junior Draftsman A,B,C, (C=lowest grade).

Hiring practices:

Personnel are usually procured from within the plant. Job openings are let on a bid basis. If in-plant personnel do not bid for positions then existing applications from the employment office are reviewed.

Training practices:

Periodic formal courses are given in various phases of drafting; however, informal on-the-job training is performed throughout the year.

Promotion practices:

Periodic review (six months) determines promotions. Examples of salaries: Junior Draftsman "C" _____ $425.00 per month, Draftsman "C" ____ $459.00 per month, General Draftsman "C" ____ $494.00 per month, Senior Draftsman ____ $530.00 per month, (salaries are based on 40 hour work week).

Physical facilities:

Facilities are air conditioned, clean, and well lighted. Crowding conditions do exist. This department will be moving to new facilities in the near future.

Furniture:

Hamilton Auto Shift tables are used throughout the area. Stools are upholstered. A large light table is available.

Equipment:

Parallel straightedges and track type drafting machines are used. Electric erasers are standard. A microfilm camera, reader, and printer is located within the area. A dry photo copier is available for producing adhesive back stick on letters, views from drawings, formats, etc.

Drawing Material:

Most of the structural drawings are on vellum. Cloth and polyester films are used on some jobs. Extensive use is made of wash-off reproducible polyester film.

Drafting room manual and other references:

A company standards book is used.

Standards:

The company standards book is based on American Standards Association documents.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Most of the lettering is done freehand. Wrico, Varityper and press on letters are used on some drawings. Lettering is usually vertical upper case. Standard notes, title blocks, and revision blocks are frequently applied with adhesive back reproducible material.

To what extent is ink used in this area?

Only about five percent of the structural drawings require ink.

Simplified drafting observed:

Simplified drafting was observed in the detailing of threads, springs, and omission of repetitive detail.

To what extent are computer devices used in this area:

Computer devices are used to keep an up-to-date record of the progress of each drawing.

Method of handling changes and revisions:

Changes are done by group leaders.

System of storage for drawings:

Originals are maintained. Microfilm is used for reference and security.

Number of women employed in this occupational area:

One.

Detail drafting practices:

1. An interesting technique used in this area involves the transfer of a view or other information from one drawing that has been completed to another drawing that is being generated. A dry photocopier used in conjunction with adhesive back reproducible copy material is available for this process. The desired view is copied from the completed drawing onto the adhesive back material. The adhesive back material which now contains the view is adhered to the new drawing.

2. In drawing some structural members which have a standard set of holes or operations, time is saved by omitting the exact detail from the drawing of the structural member. Instead, a note is given which refers the fabricator to a standard detail sheet. The fabricator then pulls the standard detail sheet from his files and proceeds to perform the operations.

Company Code: M

Occupational Area Observed: Structural Drafting
(Nature of work)

Number of employees in this area: 8

System of organization:

A fairly unique approach is used in the drafting activities in this company--the company engineering personnel do some detailing, but a good portion of their time is spent in coordinating projects. Much of the drafting work is sent out to job shops in the local area and on occasion work is sent to job shops on the west coast.

Job classifications:

Project Engineer, Structural Draftsman, Mechanical Draftsman.

Hiring practices:

The personnel turn-over rate is extremely low in this company. Source of personnel is through local employment agencies and newspaper ads. Every attempt is made to employ experienced engineers and draftsmen rather than inexperienced personnel.

Training practices:

At the present time no training is performed.

Promotion practices:

Promotion practices are not regimented at this time.

Physical facilities:

Facilities are air conditioned, clean, and moderately crowded. Lighting is slightly substandard.

Furniture:

Standard six foot wood tables are used. About fifty percent of the stools are without backs. Stools are upholstered.

Equipment:

Parallel straightedges are used on most tables. Two or three tables are equipped with drafting machines. Two desk calculators are available. Electric erasers are available.

Drawing Material:

The majority of the work is done on vellum. Some use is made of polyester film reproducibles to facilitate changes. In addition, standard basic details are reproduced on intermediates and other features are added to the intermediates before final prints are made.

Drafting room manual and other references:

A standard drafting room manual is not used by this company; however, the American Institute of Steel Construction Documents are used extensively as reference. Smolley's Combined Tables are used extensively.

Standards:

Some jobs require drawings prepared on the basis of Military Standards.

Observed use of templetes, appliques, lettering aids, and other time saving devices:

Most of the lettering is done freehand. Some ink stamps are used. Symbol templates, circle guides, and bolt and nut templates are used.

To what extent is ink used in this area?

Ink is not used to a significant degree in this area.

Simplified drafting observed:

Omission of repetitive details is practiced.

To what extent are computer devices used in this area:

None.

Method of handling changes and revisions:

Changes are made by general drafting personnel.

System of storage for drawing data:

Originals are maintained in flat files.

Method of checking drawings:

Drawings are checked by project engineers.

Number of women employed in this occupational area:

None.

Company Code: N

Occupational Area Observed: Structural Drafting
(Nature of work)

Number of employees in this area: 4

System of organization:

A central drafting room approach is used, and about fifty percent of the design and drafting work of the company is performed in this room. The balance of the work is done by local job shops and by job shops on the west coast.

Job classifications:

Drafting Supervisor, Senior Draftsman or Journeyman, Junior Draftsman or Apprentice.

Hiring practices:

Personnel are procured from local companies and from companies in other states. Apprentice personnel are sometimes recruited from local colleges. The supervisor expressed a need for qualified personnel to fill existing vacancies.

Training practices:

Informal on-the-job training is performed.

Promotion practices:

Promotion practices are not regimented in this company.

Physical facilities:

Facilities are air conditioned, clean, moderately crowded, and well lighted.

Furniture:

Five foot, angle iron base, fixed top tables are used. Flat files are used for storage. Upholstered stools are used.

Equipment:

Drafting machines and parallel straightedges are equally used in this company. A mechanical calculator is available. Mechanical lead of the style which eliminates the need to sharpen lead was observed in use.

Drawing Material:

The majority of the work is done on vellum. On occasion, intermediates are made on reproducible film to facilitate changes.

Drafting room manual and other references:

A standard drafting room manual is used. In addition, the standard AISC manuals are used extensively. Smolley's Combined Tables are used extensively.

Standards:

Standards, other than AISC documents, are not used.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Most of the lettering is done freehand. Symbol templates, circle guides, and nuts and bolts templates are used. Limited use is made of ink stamps.

To what extent is ink used in this area?

To no significant extent.

Simplified drafting observed:

Omission of repetitive detail is accomplished through notation.

To what extent are computer devices used in this area?

To no significant extent.

Method of handling changes and revisions:

The originator makes all necessary changes.

Method of checking drawing data:

The Supervisor or one of the Senior Draftsmen check drawings.

System of storage of drawing data:

Original vellums are maintained.

Number of women employed in this occupational area:

None.

SUMMARY OF PRACTICES OBSERVED IN STRUCTURAL DRAFTING

Observations in structural drafting in Maricopa County point out that, while a significant amount of structural work is done in this area, the number of draftsmen employed in certain leading companies is not sufficient to perform all the drawing data required for the company projects. This leaves much of the work to be sent to local job shops or job shops on the west coast. Observations indicate that a need exists for a limited number of trained, preferably experienced and highly competent, structural draftsmen in Maricopa County.

Generally, the central drafting room approach is used for the organization of drafting activities. Job classifications are extremely flexible in this area. Usually experienced personnel are recruited to fill job vacancies. One company is conducting an informal apprenticeship program. Two of the three companies observed do not have specific promotion policies. One company uses the periodic review system as a basis for promotions.

Physical facilities are air conditioned, clean, and well lighted in most companies. Moderately crowded working conditions exist. One facility is equipped with Hamilton Auto Shift tables, while the other companies use standard drafting tables. Drafting machines and parallel straightedges receive about equal usage in the structural drafting areas. The track type drafting machine is favored by many draftsmen.

Extensive use is made of vellum. Polyester film intermediates are widely used. Ink is not used to a significant degree in the structural areas observed. Most of the lettering is done freehand. Templates are used extensively. Simplified drafting techniques are generally limited to omission of repetitive detail. Computer devices are not used to a significant degree in this area.

Drawings are usually checked by project engineers or drafting supervisors. General drafting personnel make revisions. One company observed is changing to the microfilm system for the storage of drawing data.

Women account for approximately three percent of the personnel employed in the structural drafting occupations observed.

CHAPTER VI

ARCHITECTURAL DRAFTING

This area of drafting deals with the planning and drawing of the artistic, structural and utilitarian features of buildings. Architectural draftsmen are usually employed by a firm that specializes in a certain type, size, or cost classification of structure such as small houses, supermarkets, schools, apartments, office buildings or industrial buildings.

Specifically the work consists of making presentation drawings for the architect to show to clients, preparation of working drawings, including plot plans, floor plans, elevations, sections, details and written specifications, upon which the contractor bases his bids and according to which he erects the building.

Observations in this area involved two companies which employ a total of 33 designers and draftsmen.

Company Code: P

Occupational Area Observed: Architectural Drafting
(Nature of work)

Number of employees in this area: 12

System of organization:

The group approach is used. A group is assigned to develop each of the housing projects in various cities.

Job classifications:

Each group is lead by a group or squad leader. Otherwise, specific job classifications do not exist.

Hiring practices:

Permanent employment is limited to graduate architects. Senior architectural students are hired during the summer months. Personnel are procured from all parts of the country.

Training practices:

No training program is in effect.

Promotion practices:

Personnel are evaluated on a continuing basis rather than a periodic basis. Promotion is based on productivity.

Physical facilities:

Facilities are extremely modern and relatively spacious. Lighting is adequate. Overhead lighting and natural north light is supplemented by adjustable table lamps.

Furniture:

Standard (horizontally oriented) tables are used. Flat files and tube files are used for storage.

Equipment:

The majority of work is done with parallel straightedges. Two drafting machines were observed. A white print machine is available. Electric erasers are standard equipment.

Drawing Material:

Most of the drawings are on vellum. Drawing originals are usually reduced 50% to xerox copies.

Drafting room manual and other references:

A standard drafting room manual is not used; however, standard details (8 1/2 by 11 book form) are used by each group. All working drawing sections are referenced to these standard details. Other references include an extensive file of manufacturer's catalogs and technical manuals.

Standards:

Architectural Graphic Standards are used.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Most of the lettering is done freehand. Style of lettering is varied according to personal preference; however, clarity is a must. Room labels and titles are usually applied with transfer type, this company has special sheets of transfer type made up for symbols, special lettering, etc. Mechanical lettering is used to a limited extent.

To what extent is ink used in this area?

Ink is used to some degree in this company; Leroy lettering, some line work, etc.

Simplified drafting observed:

No simplified drafting practices were observed.

To what extent are computer devices used in this area:

Computers are used to analyze design recommendations as presented by persons who evaluate experimental houses designed and operated by this company.

Method of checking drawing data:

Drawings are checked by group leaders.

Method of handling changes and revisions:

Changes are usually handled by the originator.

System of storage of drawing data:

Originals are maintained in storage.

Number of women employed in this occupational area:

None.

Company Code: O

Occupational Area Observed: Architectural Drafting
(Nature of work)

Number of employees in this area: 21

System of organization:

Central drafting room system is used. On occasion, mechanical drafting (air conditioning and plumbing) is done by other firms.

Job classifications:

Designers (architectural, structural, mechanical) Senior Draftsman, Junior Draftsman.

Hiring practices:

Personnel are usually procured through routine employment applications. On occasion the service of an employment agency is utilized. The company does not hire inexperienced personnel as a general rule; however, inexperienced architectural degree people are sometimes brought into the firm.

Training practices:

A limited amount of informal on-the-job training is performed.

Promotion practices:

Promotion practices are not regimented in this company.

Physical facilities:

Facilities are air conditioned and well lighted. Space is adequate.

Furniture:

Drawing tables are of the wood, horizontally oriented variety. Bookcases, filled with reference material, are scattered through the drafting area.

Equipment:

Parallel straightedges are used by most of the draftsmen. One drafting machine and two T-squares were observed in use. About 50% of the draftsmen use electric erasers. Adjustable table lamps are used on most tables.

Drawing Material:

The majority of drawings are on vellum. Some government jobs require pencil on cloth.

A good deal of roll stock sketching paper is used.

Drafting room manual and other references:

A standard drafting room manual is not used; however, a multitude of manufacturer's catalogs and manuals such as AISC documents are used extensively.

Standards:

Government Standards apply to some jobs.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Most of the lettering is done freehand. Lettering templates are occasionally used for lettering titles. Adhesive back commercial letters are available. Symbol templates and circle guides are used. Ink stamps for title blocks are used on odd size drawings.

To what extent is ink used in this area?

Ink is not used to a significant extent.

Simplified drafting observed:

None.

To what extent are computer devices used in this area:

Computer devices are not used to a significant extent.

Method of checking drawing data:

Checking is performed by job captains.

Method of handling changes and revisions:

Revisions are usually done by the originator.

System of storage of Drawing data:

Orignials are maintained in a honeycone type file. Older drawings (prior to 1935) have been stored on microfilm.

Number of women employed in this occupational area:

One.

Detail drafting practices:

1. Isometric drawings are used to a significant extent on working drawings.
2. Sections through concrete are shaded in with colored pencil to produce contrast on reproductions.

SUMMARY OF PRACTICES OBSERVED IN ARCHITECTURAL DRAFTING

Due to time limitations, the observations in architectural drafting were not comprehensive; therefore, the reader should be aware that additional study within this area might bring to light facts that have not been presented in these reports.

Of the companies observed, one company is involved primarily with large scale housing projects in several states; the other company is involved in large scale commerical and public buildings throughout Arizona.

The companies use the group or squad approach to drafting activity organization. The groups work within a central drafting room.

Job classifications vary from the company that has three job classifications to the company that has one job classification. Hiring practices in the architectural drafting activities observed are unique in that one company hires only graduate architects for permanent employment. It might be pointed out that this company is involved in an unusual amount of conceptual design work. The other company, as a general rule, hires only experienced personnel. Formal training is not performed by the companies. Promotion practices are not regimented.

Facilities are modern. Standard horizontal drafting tables are used. Most of the work is done with parallel straightedges. A few drafting machines were observed. Two T-squares were observed. The majority of drawing is done on vellum.

Standard drafting room manuals are not used. Most of the lettering is done freehand. Transfer lettering and adhesive back lettering is used to a significant degree in one company. Ink is not used to a great extent in the companies observed. Simplified drafting techniques and computer devices were not observed in the drawing areas. Drawings are checked by group leaders and changes are usually made by the originator. In most cases the original drawings are filed. One company is using microfilm documentation to a limited degree.

Women account for approximately three percent of the personnel employed in the architectural drafting occupations observed.

Note: Technology students should be aware that graduates of professional schools of architecture normally work as architectural draftsmen for two to five years or more before they qualify as licensed architects. Thus, during periods when employment of architectural draftsmen is at a low level, competition from these graduates will be keenly felt by the person with less training, talent, and comparable experience.

CHAPTER VII

TECHNICAL ILLUSTRATION

Technical illustration has assumed an important place in all phases of science and engineering. Technical illustrations are pictorial drawings showing products and parts of products in various stages of development. Illustrations are usually provided for product proposals and for graphic assistance during production and assembly. When the product is delivered to the customer the manufacturer supplies illustrated service, repair, and operation manuals.

Technical illustrations are based on any of the pictorial methods: isometric, dimetric, trimetric, perspective and oblique. Views may be exterior, interior, sectional, cutaway, or phantom.

It is estimated by the writer that more than one hundred and fifty technical illustrators are employed in Maricopa County. Local opportunities exist for qualified personnel in this occupational area.

Observations in this area involved two companies which employ a total of 25 illustrators.

Company Code: BB

Occupational Area Observed: Technical Illustration
(Nature of work)

Number of employees in this area: 16

System of organization:

Work is performed within a central drawing room. Jobs are assigned to the various illustrators on the basis of their past experience and competence.

Job classifications:

Department Head, Supervisors, Industrial Artist One and Two, Technical Illustrator One, Two, Three, Four.

Hiring practices:

Personnel procurement is from other companies and from within other areas in this company.

Training practices:

Some informal on-the-job training is provided.

Promotion practices:

Promotions are based on periodic performance ratings given every six months.

Physical facilities:

Facilities are air conditioned, clean, spacious, and well lighted.

Furniture:

Standard horizontally oriented drafting tables are used.

Equipment:

Drafting machines and parallel straightedges are used for drawing.

Varitype machines are available. Also a camera capable of enlarging and reducing art work is located within the department.

Drawing Material:

About 85% of all drawing is done on vellum. Some ink work is on cloth and occasionally polyester film is used on a job.

Drafting room manual and other references:

A standard Art Room Guide is used.

Standards:

Signal Corp standards are used on some jobs. Also Air Force Standards and Grumman Standards are used on occasion.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Some lettering is done freehand; however, much of the lettering originates from the Headliner type machine, the electric typewriters, or from type set by local printers. Various templates are used. The ellipse guides are used extensively. Dimetric and trimetric layout templates are made within the area. Repeated details are usually applied using the paste-up technique.

To what extent is ink used in this area?

It is estimated that 50% of the work in this area is done with ink.

Simplified drafting observed:

None, except for lettering, paste-up techniques, and use of templates.

To what extent are computer devices used in this area:

Not observed.

Method of handling changes and revisions:

Changes are generally made by the originator.

Number of women employed in this occupational area:

One.

Company Code: EE

Occupational Area Observed: Technical Illustration
(Nature of Work)

Number of employees in this area: 9

System of organization:

Most of the illustration work is done within a central drawing area. Some job shop personnel work in this area. Overflow of art work is sent to local job shops.

Job classifications:

Supervisor (Art Director), Commercial Artist, Illustrator A,B,C.

Hiring practices:

Usually no inexperienced personnel are hired. Personnel are procured through routine employment channels such as existing applications, newspaper ads, etc.

Training practices:

Training is informal and on-the-job.

Promotion practices:

Promotions are based on periodic ratings, Hourly paid personnel (illustrators) are rated every six months. Salaried personnel (commercial artists, supervisors) are rated yearly.

Physical facilities:

Overhead lighting is supplemented by adjustable table lamps. Facilities are air conditioned and moderately crowded. Illustrators work in a large room which also accommodates office type personnel.

Furniture:

Standard six foot, horizontally oriented tables are used.

Equipment:

Drafting machines are used by the majority of illustrators. An enlargement/reduction projection booth is used. A light table is available.

Drawing Material:

The majority of illustrations are drawn on vellum. Some work is done on polyester film. Drawing modifications are often done on original size reproductions. Original size drawings are 1.5 times size.

Drafting room manual and other references:

A company standards manual is used. The manual dictates items such as line weights, arrow head size, type of shading, exact style of Artist Aid, Zip-A-Tone, etc. for various jobs. Also standards are set up for drawing wiring diagrams and schematics.

Standards:

Air Force, Navy and other military standards are used when work is done for these agencies.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Most of the lettering, which includes notes, callouts, and labels is accomplished by typing on adhesive back material. Rub-on lettering is used occasionally. Isometric guides, flow diagram templates, and circle guides are used extensively.

To what extent is ink used in this area:

Most of drawings in this area are lightly penciled, then inked. Technical fountain pens such as Leroy and Rapidograph are used extensively. The use of ruling pens was not observed.

Simplified drafting observed:

None.

To what extent are computer devices used in this area:

To no significant extent.

Method of handling changes and revisions:

Changes are made by general technical art personnel.

Method of checking drawing data:

Technical writers check for technical data accuracy. Supervisors check for acceptable drawing techniques.

System of storage of drawing data:

Negatives are made of all illustrations and the negatives are permanently stored. Original artwork is stored for several months.

Number of women employed in this occupational area:

None.

SUMMARY OF PRACTICES OBSERVED IN TECHNICAL ILLUSTRATION

Observations and interviews indicate that many large manufacturing companies in Maricopa County utilize the services of technical illustrators. The background of most illustrators interviewed is interesting and varied. The prime requisites for a good illustrator seem to be: high spatial ability, good manipulative skills, a flair for art, and a basic understanding of engineering drawing which includes a comprehensive knowledge of projection systems.

Illustrators in the companies observed work in central drawing areas that are comfortable, but moderately crowded. Work assignments are based on previous experience and competence. The companies observed have several grades of illustrators, plus industrial or commercial artists ratings. The companies seek experienced personnel to fill job vacancies, but will consider personnel who have formal training but no industrial experience. Promotions are based on periodic ratings.

Furniture and equipment used in the technical illustration areas observed consisted of standard horizontal drafting tables equipped with drafting machines or parallel straightedges. A large number of time saving devices such as Varitypers, stick on symbols, transfer letters, adhesive shading, line tape, and camera processes were observed in this area.

Most of the drawing in this area is done on vellum. Company standards manuals are widely used. Other standards such as service standards and prime contractor standards are used on certain jobs. Some lettering is done freehand, but the majority of lettering is done by mechanical devices. Templates and various guides are used extensively. Ink is used extensively throughout the technical illustration areas.

Computer devices are not used in the areas observed. Drawings are usually checked by supervisors and changes are generally made by the originator. Drawing data is usually stored in negative form.

Women account for four percent of the personnel observed in this occupational area.

CHAPTER VIII

TOOL DESIGN

Tool design is a relatively specialized area within the design and drafting fields. The work consists of generating the design and drawings of special tools, gages, jigs and fixtures which may be needed to manufacture the various parts of a machine or structure in the shop.

The tool designer must be an extremely versatile mechanical designer/draftsman with an inventive mind and a broad knowledge of cams, gears, and other intricate machine elements. In addition, knowledge of machining operations is required.

Tool designers represent a rather small, but important, segment of the design and drafting population in Maricopa County. Observations indicate that the need for well qualified tool designers in the Phoenix area is reaching the critical stage.

Observations in this area involved two companies which employ a total of 20 tool designers.

Company Code: BB

Occupational Area Observed: Tool Design
(Nature of work)

Number of employees in this area: 10

System of organization:

General drafting room system of organization. Work is assigned according to ability to perform the task.

Job classifications:

Lead Tool Designer, Tool Designer.

Hiring practices:

Personnel are hired primarily through job shop contacts, and through applications filed by persons previously employed as tool designers in other states.

Training practices:

Training is performed by informal on-the-job training.

Promotion practices:

Periodic review of ability to perform assigned tasks is the basis for promotion. Average salaries range approximately $130.00 to $140.00 per week, based on a 40 hour work week.

Physical facilities:

Facilities are air conditioned, well lighted, and moderately crowded.

Furniture:

Boards are standard five and six foot horizontal type.

Equipment:

Twenty-four drafting machines are used. Electric erasers are standard equipment, adjustable table lamps are used. Microfilm readers are available in the area.

Drawing Material:

Majority of the work is done on vellum. Comparator charts are drawn in Mylar.

Drafting room manual and other references:

Several different tool design manuals are used including manuals from other major companies. Other references include a multitude of standard parts catalogs, materials handbooks, and engineering standards.

Standards:

Company engineering standards are followed; however, the nature of work does not require strict compliance with Military Standards.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Standard templates such as circle guides, fastener templates ellipse guides, and spring templates are used extensively.

To what extent is ink used in this area?

The use of ink was not observed.

Simplified drafting observed:

None.

To what extent are computer devices used in this area:

Punch tapes for numerical controlled machines are programmed in the manufacturing methods area. Occasionally a manufacturing engineer will be assigned to the tool design area to program the operations on a specific job.

Method of handling changes and revisions:

Changes are handled within the general drafting area.

Number of women employed in this occupational area:

None.

Company Code: EEE

Occupational Area Observed: Tool Design
(Nature of work)

Number of employees in this area: 10

System of organization:

The tool design group uses the composite effort approach. Jobs are assigned by the chief tool designer to the various designers on the basis of ability to perform the task. The designers are versatile, but most have a specific area of tool design that is more or less a specialty to them.

Job classifications:

Supervisor, Lead Tool Designer, Tool Designer.

Hiring practices:

Personnel are hired through job shop contacts, routine personnel recruitment, and through junior colleges.

Training practices:

Informal, on-the-job training is performed.

Promotion practices:

Promotions are based on periodic evaluations.

Physical facilities:

Well lighted, air conditioned, moderately crowded.

Furniture:

Standard horizontal tables. Table lamps.

Equipment:

Drafting machines.

Drawing Material:

Polyester film used with plastic lead.

Drafting room manual and other references:

A tool design manual is used. Other references include standard parts catalogs, Machinery's Handbook, materials handbook, spring handbooks and other standard references.

Standards:

Tool design drawings are not usually subject to the standards applied by the military; however, the company has various material and engineering practice standards.

Observed use of templates, appliques, lettering aids, and other time saving devices:

Spring templates, circle guides observed. Most lettering is done freehand.

To what extent is ink used in this area?

None.

Simplified drafting observed:

None.

To what extent are computer devices used in this area?

The writer observed the production of tapes for automatic numerically controlled machines. This company makes extensive use of automated machines in the production of parts for their product. The automation process permits operations to be performed rapidly and with more consistent precision than can be done by hand controlled methods. The tool design department in this company prepares the punch tapes that control the automated machines. The procedure for preparing these tapes is given below.

Manufacturing Operations and Tooling Forms are prepared by the production planning personnel and are sent to the programmer in the tool design area. An engineering drawing of the particular part is attached to the form. The programmer makes up the machining program from data presented as coordinate information on the engineering drawing and from the planning forms. If coordinate information is not given on the engineering drawing then the programmer must originate coordinate data. After the program forms are made up the programmer punches the control tape in a tape punching machine. The machine has a read back device that is used for checking the data punched. As a final step the tape and program sheets are sent to the machine shop where the machinist sets up the numerical controlled machine for the various operations.

Method of handling changes and revisions:

Changes are minimal and are handled within the tool design area.

Method of checking drawings:

Checking is performed by the Lead Tool Designer or Supervisor.

Number of women employed in this occupational area:

None.

SUMMARY OF OBSERVATIONS IN TOOL DESIGN

Observations were not extensive in tool design; however, it is believed that the activities observed are fairly typical of other tool design efforts in Maricopa County.

Tool design jobs are normally sent from the operations planning department to the Lead Tool Designer or Supervisor. The Supervisor then assigns the jobs to individual tool designers, taking into consideration their ability and past experience. Of the tool designers interviewed and observed, most have a general drafting background with some experience in machine shop operations. Many have experience in the tool and die manufacturing area.

Tool designers normally work in comfortable surroundings. Exceptions are when the tool design area is in or near the machine shop, then excessive noise and lack of air conditioning may be present. Furniture usually consists of standard drafting tables and stools. Tables are generally equipped with drafting machines. Very few parallel straightedges were observed in this area.

Companies observed tend to procure permanent employees through job shop contacts or from other tool design departments. Experienced personnel are preferred; however, inexperienced personnel with formal training have been recently employed in the activities observed.

Informal on-the-job training is performed in order to increase the competency of inexperienced personnel.

Many of the drawings in tool design are done on vellum. One company observed has switched to polyester film. There is a sense of urgency in tool design that calls for fast, accurate drawings. These drawings are not usually held to the high standards that are required for engineering drawings that must be delivered to the customer; nevertheless, the drawings must be legible and well executed. Most of the lettering is done freehand.

Company tool design manuals, engineering standards handbooks, standard parts catalogs, materials handbooks and other references are used by tool designers.

The use of standard templates such as circle guides, fastener templates, spring templates, and ellipse guides was observed. The use of ink was not observed in tool design. The use of numerically controlled machines is affecting job classifications and descriptions in the tool design area. Some tool design personnel observed are working full time setting up punch tape data for control of machining operations.

Checking of tool design drawings is done by the Lead Tool Designer or his assistant. Changes are handled within the general area. Original drawings are filed; however, the companies observed are changing to microfilm documentation.

No women tool designers are presently employed in the companies observed.

GENERAL SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

In this final chapter a general summary of practices observed in design and drafting occupations has been presented. In order to put the summary in the proper perspective, a brief review of the scope of the study is given:

> The writer conducted a series of in-plant observations concerning current practices utilized in seven design and drafting occupational areas. A total of twenty observations were made within sixteen companies that employ a total of 869 designers and draftsmen. The observation reports, each containing twenty-one observed factors, were presented as the body of the writing. The primary purpose of the study was to assist design and drafting teachers in their effort to obtain knowledge of current practices utilized in various design and drafting occupations.

In the general summary a brief statement has been made concerning each observed practice.

After careful study of the general summary, several conclusions have been drawn.

As a result of the conclusions, and other general observations of the writer, several recommendations have been made. It should be pointed out that recommendations convey the personal opinion of the writer and should be regarded as such.

GENERAL SUMMARY

1. A breakdown of occupational areas observed and the NUMBER OF DESIGNERS AND DRAFTSMEN OBSERVED in these areas is as follows.

Electro-mechanical Design and Drafting	316
Mechanical Design and Drafting	247
Civil Drafting	200
Structural Drafting	28
Architectural Drafting	33
Technical Illustration	25
Tool design	20

2. DRAFTING ROOM ORGANIZATION generally follows the composite drafting room approach or the project/group approach. The larger companies generally favor the project/group method, while the smaller activities use the composite or single drafting room approach.

3. JOB CLASSIFICATIONS vary from company to company, usually at least three grade levels are provided for both designers and draftsmen.

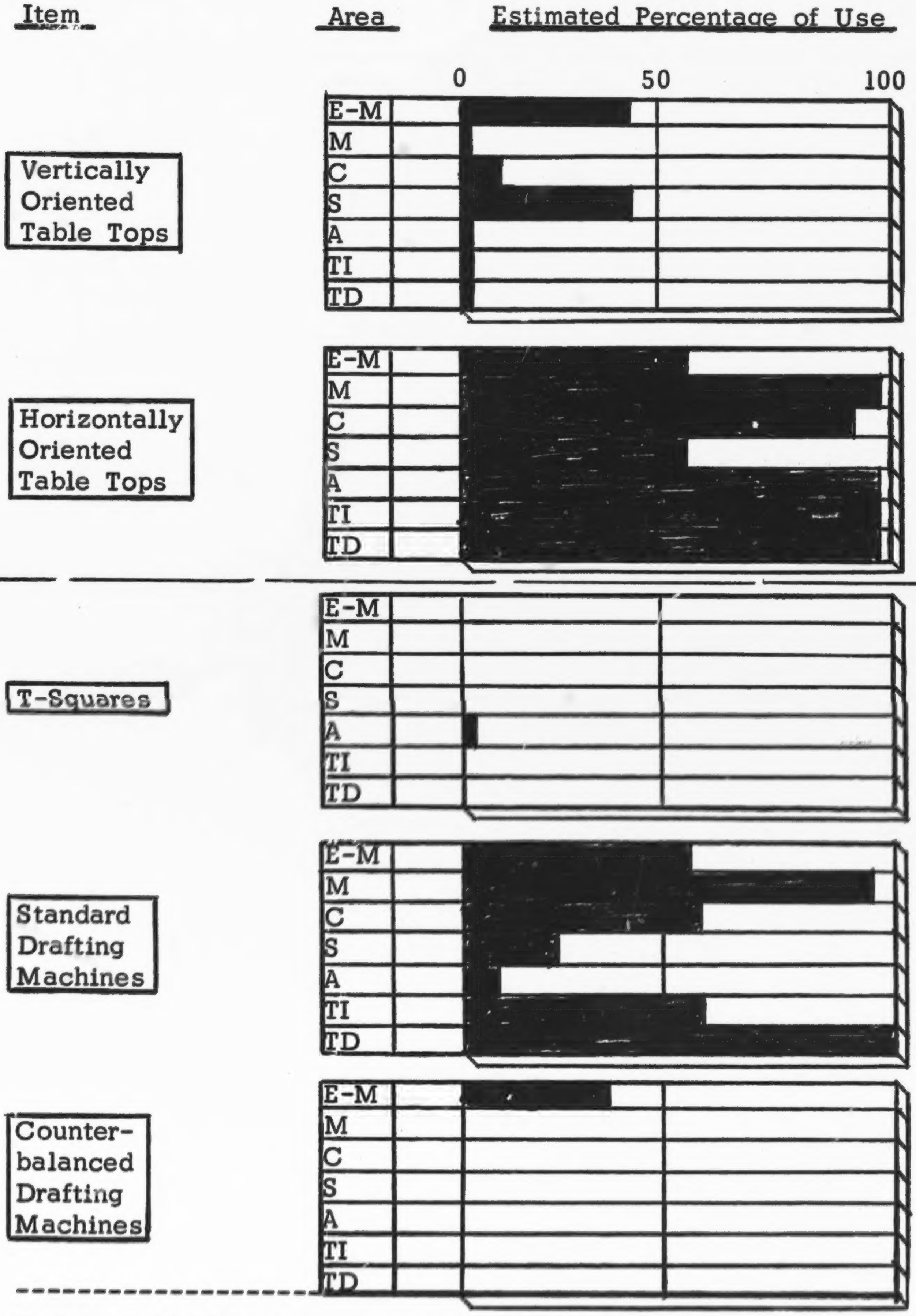
4. HIRING PRACTICES vary widely among the companies observed. Larger companies seem to provide more flexibility in the hiring of younger and more inexperienced personnel. Several companies require pre-employment tests. (see Appendix B)

5. Four of the sixteen companies observed provide some formal TRAINING for their design and drafting employees.

6. PROMOTION PRACTICES in the majority of the companies observed are for the most part regimented. Use of a six month rating scheme as a basis for promotion is widespread. (see Appendix C)

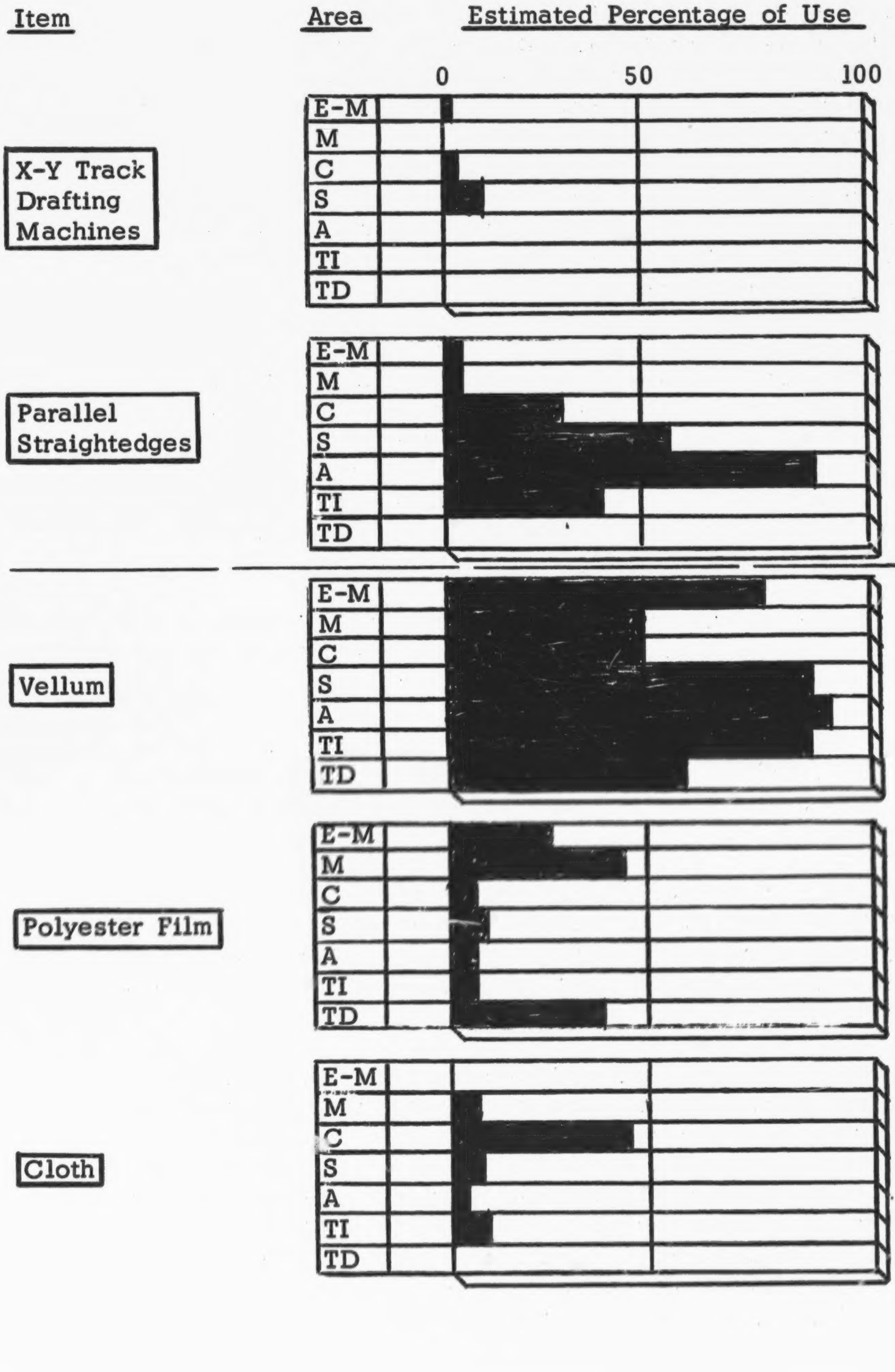
7. All PHYSICAL FACILITIES observed were air conditioned, clean, and adequately lighted. Crowded working conditions exist in several facilities. Several drafting rooms were being rearranged or moved to provide more working space.

8,9,10. FURNITURE, EQUIPMENT, AND DRAWING MATERIAL used in the observed design and drafting occupations varies in certain respects. A summary of variance is shown in the Percentage of Use Charts below:



Code: E-M=Electro-mechanical; M=Mechanical; C=Civil; S=Structural; A=Architectural; TI=Technical Illustration; TD=Tool Design

(Charts continued)


Item
Area
Estimated Percentage of Use
0
50
100
X-Y Track Drafting Machines
Parallel Straightedges
Vellum
Polyester Film
Cloth
E-M
M
C
S
A
TI
TD

11. Most companies use DRAFTING ROOM MANUALS. Many of the manuals are based on Military Standards. Other references such as, textbooks, parts catalogs, design handbooks, material and process manuals and standard data tables are usually found in drafting rooms.

12. Military STANDARDS and the American Standards Association documents are widely used throughout the companies observed. The electro-mechanical and mechanical activities are particularly controlled by Military Standards.

13. While most of the LETTERING is done freehand, there appears to be a trend toward utilization of more mechanical lettering aids such as, typed letters on adhesive back material, the transfer and stick-on lettering process, and preprinted standard notes. Several companies observed are using symbol and standard parts APPLIQUES to a limited extent. The use of circle and symbol TEMPLATES is widespread. All printed circuit drawings observed were taped. Experimentation with photo drawing was observed in two companies.

14. INK is used extensively by personnel in civil drafting and technical illustration. The other personnel observed use ink on a very small percentage of their drawings.

15. SIMPLIFIED DRAFTING practices are not widely used by the companies observed. Omission of unnecessary views, elimination of repetitive detail by notation, and omission of section lines was observed in several cases.

16. Two of the sixteen companies observed are experimenting with COMPUTER DEVICES that will be used to automate drafting. Several companies are using computer devices to calculate initial design data, control drawing progress records, and to store parts data.

17. Several larger companies observed have separate CHANGE ORDER groups. Smaller companies use general drafting personnel for making drawing changes.

18. Three of the five companies employing more than 75 Designers and Draftsmen use personnel classified as CHECKERS to review design/drafting techniques and procedures. Other companies, large and small, use either Project Engineers, Lead Draftsmen, Squad Leaders, of Chief Draftsmen to check drawings.

19. Many of the larger companies observed are changing to microfilm as a SYSTEM OF STORAGE FOR DRAWING DATA; however, most companies maintain original drawings and reproduce from the original drawing, or reduced size autopositives. The use of paper and film intermediates is widespread throughout all areas observed.

20. About five percent of the designers and draftsmen in the occupational areas observed are WOMEN.

21. Several UNIQUE DETAIL DRAFTING PRACTICES were observed and illustrated in this study.

GENERAL CONCLUSIONS

1. Accurate figures as to the number of Draftsmen employed in Maricopa County are not readily available; however, interpolation of projections provided by the Arizona State Employment Service indicate that about 1700 draftsmen should be employed in Maricopa County during 1966.

2. Observations and interviews suggest that a shortage of well qualified draftsmen has existed in Maricopa County for many months, and there are indications that this condition will continue in the future. This shortage is particularly acute in the electro-mechanical and mechanical design and drafting areas.

3. As with many occupations, the labor market for designers and draftsmen is sensitive to business fluctuations.

4. Most companies will hire inexperienced drafting personnel; however, several companies observed will hire only draftsmen with considerable work experience.

5. Those employers observed who hire inexperienced drafting Trainees directly out of high school, generally offer $1.50 to $2.00 per hour as a starting wage. Trainees with two years of college work in drafting usually start at $2.00 to $2.50 per hour. Senior Draftsmen are usually paid between $3.50 and $5.00 hourly. Salaries for Designers vary from $500 to $900 per month.

6. Job shops usually pay substantially higher wages than other employers, but work in these places is intermittent.

7. The majority of companies observed use "occupational osomosis" as a means of providing on-the-job training.

8. Most Chief Draftsmen are seeking methods to provide more effective training programs for employees and potential employees.

9. A competent Designer/Draftsman must understand the processes of fabrication, assembly, and servicing of the product which he helps to design.

10. The typical drafting room is moderately crowded, clean, well lighted, and air-conditioned.

11. There is variation in furniture, equipment, and drawing material used in design and drafting occupations.

12. The Designer and Draftsman uses drafting room manuals, engineering handbooks, manufacturer's catalogues, charts, and mathematical tables to help him in his work.

13. Military Standards are becoming increasingly important to large manufacturing companies in Maricopa County.

14. Many companies are not realizing the full potential of appliques, lettering aids, and other time saving devices.

15. Automated (Computerized) drafting is undoubtedly inevitable, especially in printed circuit design and drawing, schematic diagrams, block diagrams, harness drawings, sheet metal drawings, template scribing, and space layouts to determine clearances; however, at the present time most of the major companies observed are not productively engaged in automated drafting techniques. Nevertheless, these companies are successfully competing on the world market.

16. Women are employed as draftsmen by a number of companies in Maricopa County. Most employers consider this an excellent and growing field for qualified women.

17. An informal study comparing the content of several recently published drafting textbooks, versus detail drafting practices observed in industry indicates that:

> With the exception of information relating to microfilm requirements, automated drafting, and Military Standards, textbooks are generally abreast of industry in terms of content.

RECOMMENDATIONS

1. Design/drafting technology instructors and design/drafting personnel in industry should establish a reciprocal "open door" policy.

2. Design/drafting instructors should seek employment in a different industrial drafting department each summer.

3. The practice of Industrial Cooperative Education (part time industrial employment for students) should be expanded at the junior college level.

4. Instructional programs should parallel industrial situations as much as possible. This can be accomplished in part by the following measures:

   A. Secure a physical facility for drafting that is clean, well-lighted, air conditioned, quiet, and which contains adequate floor space. Equip the facility with a variety of furniture and equipment that is representative of furniture and equipment found in a cross section of industrial drafting rooms. (See Appendix A)

   B. Have students frequently work from actual engineering sketches, notes, and verbal instructions, thus eliminating the textbook copying approach. This does not preclude the use of good textbooks for reference use. Make available American and Military Standards, parts catalogs, handbooks, and other reference material.

   C. Teach legibility and reproducibility of lines and letters by grading checkprints rather than original drawings. Make periodic assignments that require knowledge of microfilming requirements.

   D. Emphasize that drawings are used to fabricate, assemble, sell, and service a particular product; therefore, the end product must always be uppermost in mind. "Pretty"working drawings that are incomplete, or that lack functional dimensions are useless.

E. Introduce the fact that most drawings in industry must undergo revision. This can be accomplished by "building in" revisions in drawing assignments.

F. Encourage experimentation with templates, appliques, scissors drafting, and any other cost reducing methods of making drawings.

G. Use pre-printed titleblocks, and vary drawing materials. Show the various applications of "intermediate" drawings.

5. A yearly review of design and drafting technology programs should be made by educators in cooperation with major employers of design and drafting personnel.

APPENDIX "A"

EQUIPMENT GUIDELINES FOR DESIGN AND DRAFTING TECHNOLOGY PROGRAMS.

The following list of recommended equipment for design and drafting technology programs has been formulated as a by-product of a project that involved ten weeks of direct observation of current practices utilized in various design and drafting occupations. The occupational areas observed included: electro-mechanical design and drafting, mechanical design and drafting, civil drafting, structural drafting, architectural drafting, technical illustration, and tool design. The observations involved sixteen industrial firms which employ a total of eight hundred and sixty nine designers and draftsmen.

Equipment throughout design and drafting occupations is not diversified to a great extent. The greatest diversity is noted in the type of drafting tables used, the type of drafting machines used, and whether use is made of drafting machines or parallel straightedges.

Based on the above observations, it is the opinion of the writer that students in drafting technology programs should become proficient in the use of horizontally oriented and vertically oriented drafting tables, standard drafting machines, track type drafting machines, counterbalanced drafting machines, and parallel straightedges. This proficiency can be obtained by equipping programs with a variety of equipment, then rotating students to various work stations. The cost of such a program may be initially higher than the standard approach, but the end product, a succession of students who are versatile in many industrial situations, is well worth the cost.

The following equipment list is sufficient to accommodate thirty students.

Quantity	Item	Description	Estimated Unit Cost
10	Table, Drafting	Vertical, 90 degree automatic adjustable top, 38" x 48" top size	200.00
20	Table, Drafting	Horizontal, 15 degree adjustable top, 38" x 48" top size, 6-drawer unit, with locks	150.00
1	Table, Layout	38" x 72" top size	116.00
1	Table, Tracing	Lighted, top size approximately 24" x 36", with parallel straightedge	150.00
5	Machine, Drafting	Vertical, with counterweight scale arm, automatic indexing head, 24" arm	152.00
10	Machine, Drafting	X-Y Track type, 36"	170.00
9	Machine, Drafting	Standard, 24" arm, automatic indexing head	85.00
1	Machine, Drafting	Standard, 24" arm, automatic indexing head. Left hand	85.00
5	Straightedge, Parallel	48"	25.00
1	Machine, Chalk board, Drafting	4' x 6' : X-Y Track type	200.00
10	Chair, Drafting Posture	Adjustable (to correlate with vertical drafting tables listed above) Upholstered seat and back	45.00
22	Stools, Drafting	Adjustable, 27" to 33", with upholstered back and seat	30.00
2	Cabinet, Flat File	Five Drawer	160.00

Quantity	Item	Description	Estimated Unit Cost
1	Cap, Flat File	To match flat file above	23.00
1	Base, Flat File	To match flat file above	19.00
1	Marking and Engraving Set	----------------------	15.00
3	Micrometer	.0 to 1.0 by .001	14.00
3	Micrometer	1.0 to 3.00 by .001	14.00
6	Calipers, Inside	6"	3.00
6	Calipers, Outside	6"	3.00
2	Pantograph	Metal	10.00
1	Planimeter, Polar	---------------------	50.00
10 Sets	Pens, Technical Fountain	6 points 00,0,1,2,3,4	14.00
1	Punch, Paper	3 Hole, Adjustable	13.00
1	Sign Maker Set	Including six assorted templates	25.00
6	Compass, Beam	12" x 30"	3.00
2	Compass	Quick Set	6.00
4	Curves, Adjustable	12"	1.00
2 Sets	Curves, Irregular	4" through 10"	20.00
2	Divider, Proportional	8"	15.00
3	Gages	Thread and Wire	5.00
2	Sharpeners, Pencil	Draftsmen	8.00
2	Protractors	6"	1.00
2	Scales, Architect's	12" Triangular	2.00

Quantity	Item	Description	Estimated Unit Cost
1	Cabinet, File	Four drawer, legal size, with lock	85.00
1	Cabinet, Storage	Vertical, two door 36" x 24" x 78"; with lock	75.00
1	Desk, Instructor's	Twin pedestal	100.00
1	Chair, Instructor's	Upholstered, with arms	50.00
1	Rack, Magazine	Four shelves	25.00
2	Bookcase, Library	36" x 12" x 42"	50.00
1	Typewriter	Electric, with interchangeable type elements	400.00
1	Calculator	Rotary, Fully Automatic	1100.00
1	Machine, Reproduction	With stand and storage base, anhydrous ammonia developing system, reverse switch, blower delay, paper rod and cutter, and dust cover	2500.00
2	Tube, Storage	36"	8.00
1	Projector, Overhead	1000 watt, heavy duty, with adjustable tilt head	400.00
1	Cart, Projector	To match above projector	40.00
1	Transparency Maker	Dry process, heat transfer type	375.00
1	Cutter, paper	36"	100.00
1	Dispenser, Paper	42"	22.00
30	Eraser, Electric	With air cooled motor	21.00
30	Lamp, Table	Adjustable	25.00
2	Scale, Civil Engineers	12" Triangular	2.00
2	Scale, Mechanical Engineers	12" Triangular	2.00

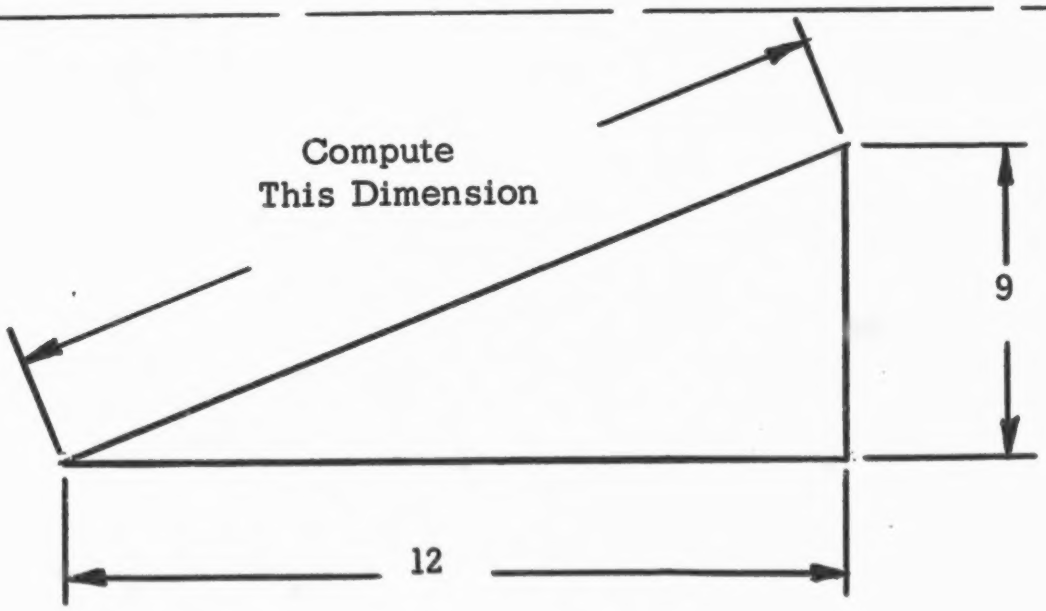
Quantity	Item	Description	Estimated Unit Cost
2	Dispenser, Tape	For 3/4" x 6" Roll	2.00
2	Tape, Measuring	100', Steel	8.00
2	Tape, Measuring	10', Steel	2.00
10	Lettering Sets	With Guide, Scriber and Straightedge. Guide size .100 in., .140 in., .240 in.	10.00
3	Shears, Trimming	9" Blade	8.00
15	Templates	Nuts and Bolts	2.00
15	Templates	Architectural	2.00
15	Templates	Isometric	2.00
15	Templates	Electronic	2.00
6	Triangles, 45°	8"	1.00
6	Triangles, 30-60°	10"	1.00
6	Triangles, Adjustable	10"	3.00
		ESTIMATED TOTAL COST	17,965.00

It should be noted that standard reference material such as American and Military Standards should be included in the initial budget for equipping a design and drafting technology program.

It is assumed that the student will purchase the following personal equipment:

Blade(s), Drafting Machine
Triangles, Regular and Adjustable
Scales, Mechanical Engineer's and Architect's
Duster, Draftsman's
Shield, Erasing
Dividers
Compasses
Pointer, lead
Guide, Lettering
Protractor
Pencils, Mechanical
Erasers
Template, Circle
Tape, Drafting

Print the alphabet and numerials. Use vertical commerical Gothic letters.



Add these numbers:

$$\begin{array}{r} 1\ 1/2 \\ 2\ 3/8 \\ \underline{2\ 1/16} \end{array}$$

Express the following numbers as three place decimals:

1/2 =

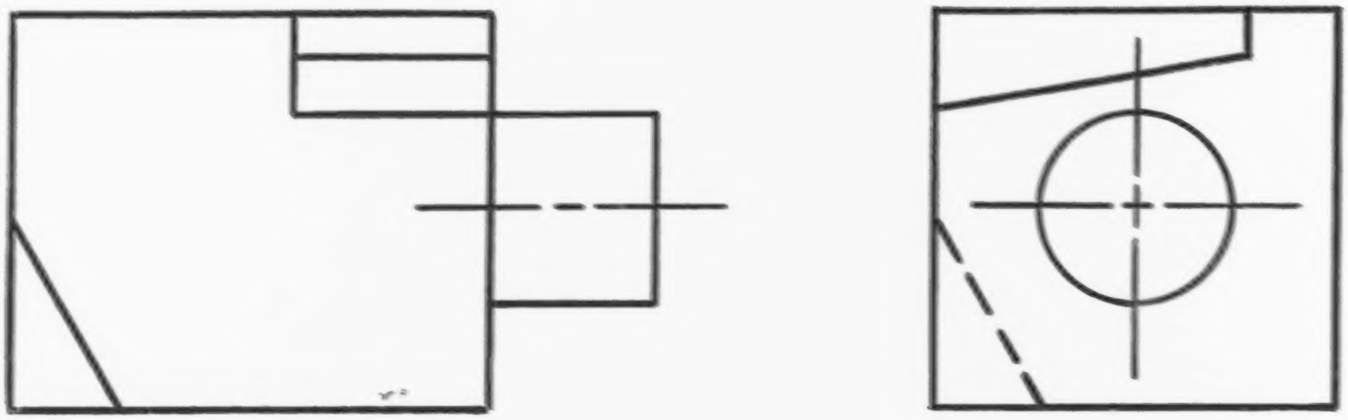
1/4 =

1/8 =

Multiply the following numbers:

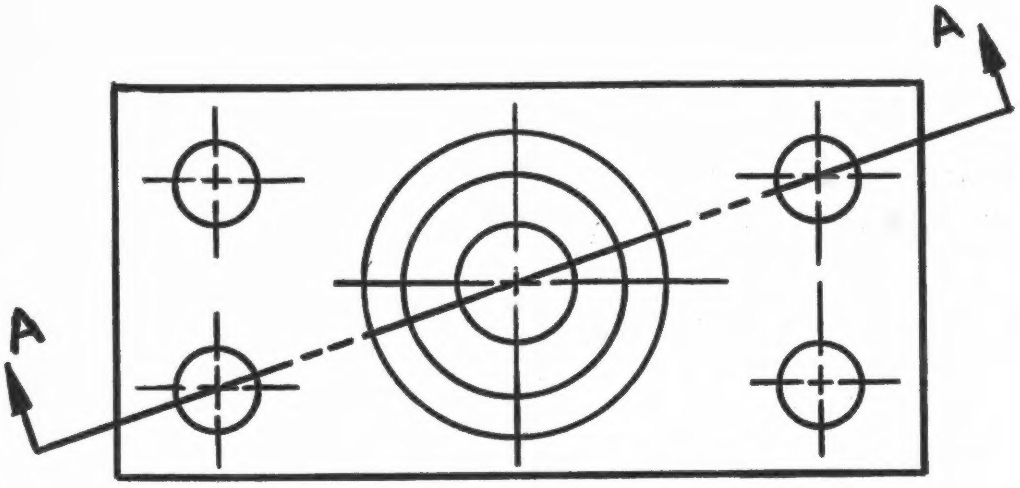
1 1/2 X 2 1/4 =

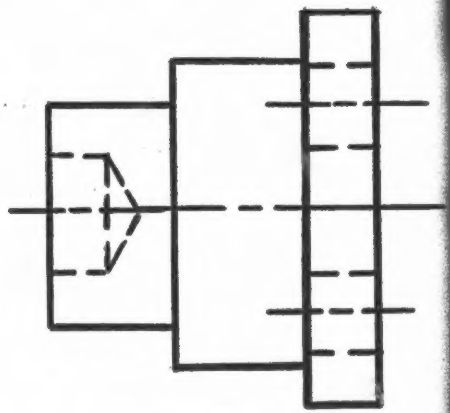
Print your name.



Draw the plan view of the object.

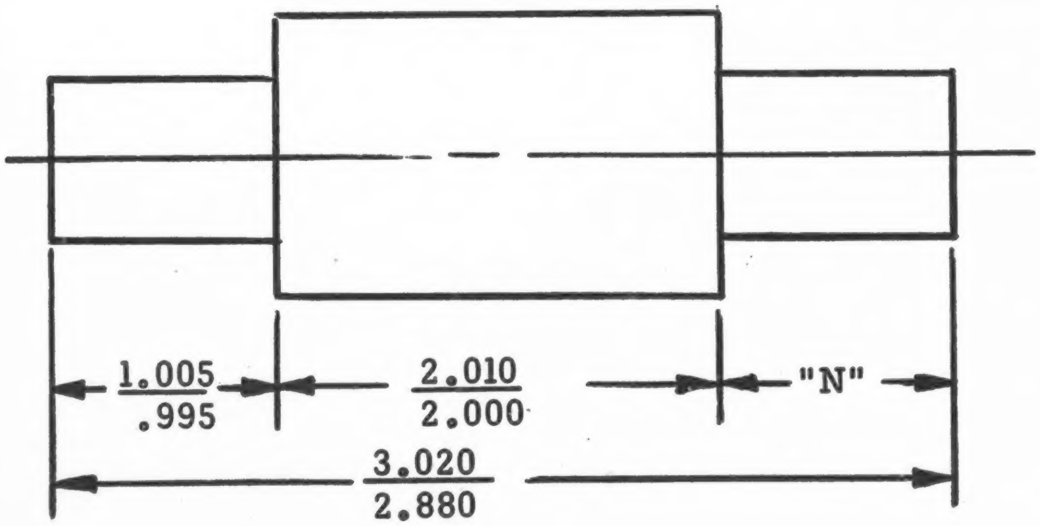
Freehand sketch is acceptable.





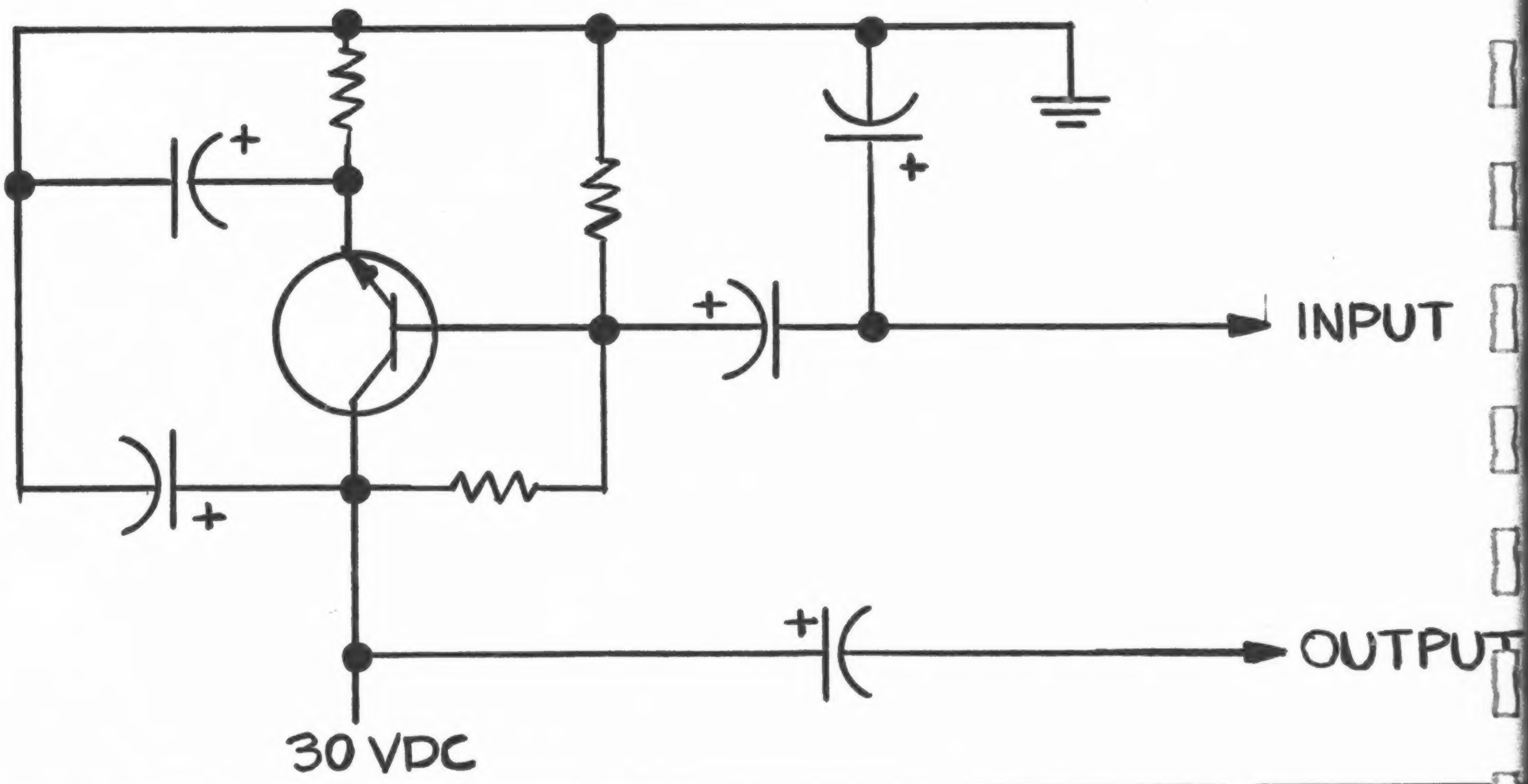
SECTION A-A

Draw section A-A.
Freehand sketch is acceptable.


1.005
.995
2.010
2.000
"N"
3.020
2.880

Compute the limits of factor "N" when the overall dimension of the object is at maximum and minimum material conditions.

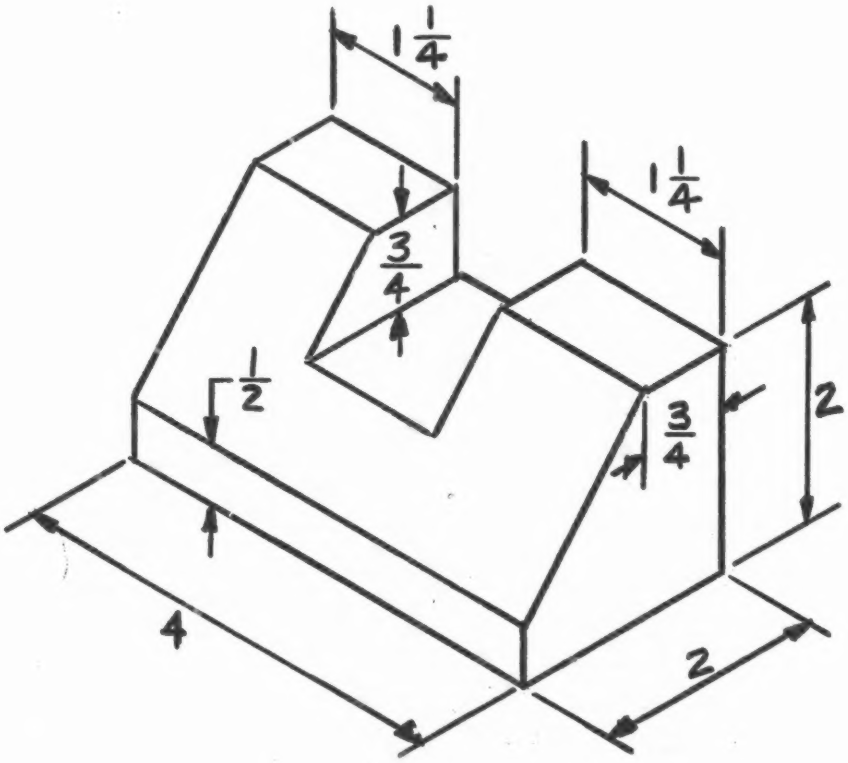
In the space provided below, rearrange the circuit to show inputs on the left hand side and the outputs on the right hand side.


INPUT
OUTPUT
30 VDC
+
+
+
+
+

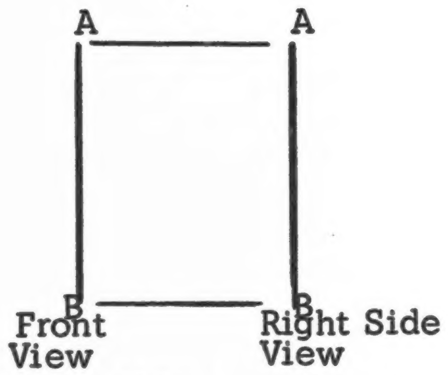
Name:

Name:______________________________

In the space above, draw the front and side orthographic views of the given object.
Scale: 1/2" = 1"   Dimension and identify front and side views.

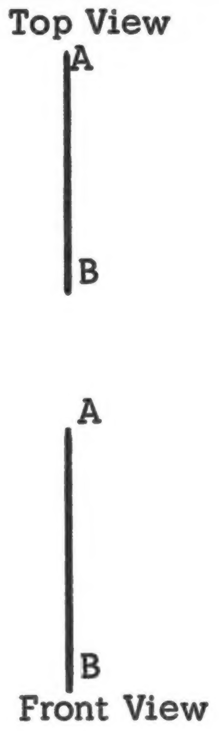

1 1/4
1 1/4
3/4
1/2
3/4
2
4
2

SPATIAL PERCEPTION


A
A
B
B
Front View
Right Side View

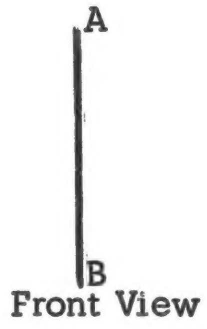
Is line "AB" a vertical line?

______Yes
______No
______I don't know


Top View
A
B
A
B
Front View

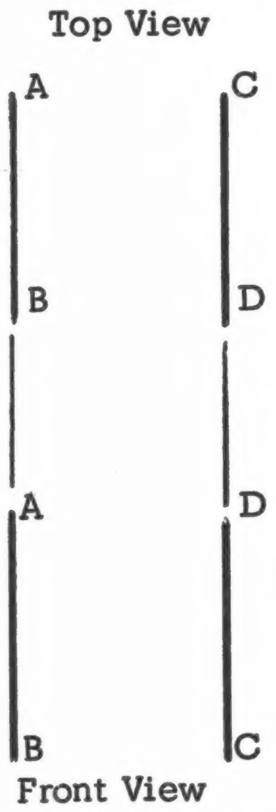
Is line "AB" a vertical line?

______Yes
______No
______I don't know


A
B
Front View

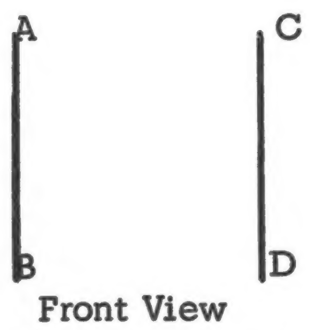
Is line "AB" a vertical line?

______Yes
______No
______I don't know


Top View
A
C
B
D
A
D
B
C
Front View

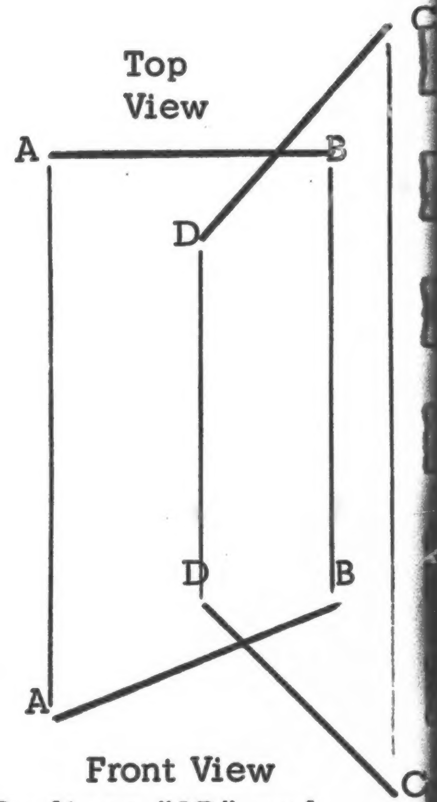
Are lines "AB" and "CD" parallel to each other?

______Yes
______No
______I don't know


A
C
B
D
Front View

Are lines "AB" and "CD" parallel to each other?

______Yes
______No
______I don't know


Top View
A
B
D
D
B
A
C
Front View

Do lines "AB" and "CD" intersect?

______Yes
______No
______I don't kno

APPENDIX "C"

SAMPLE PERFORMANCE RATING GUIDE USED FOR PERIODIC EVALUATION OF DRAFTSMEN

In most of the occupational areas observed the draftsmen are periodically evaluated or rated. These ratings are used as a basis for promotion. Generally, the hourly paid personnel are rated every six months, while the salaried personnel are rated yearly. Salaried personnel are usually senior level designers, supervisors, and engineers.

A careful study of the criteria on which the draftsman's performance is based should provide valuable information for technical drafting instructors.

A sample performance rating guide is provided on the following pages.

RATING GUIDE

Position: DETAIL DRAFTSMAN

Job Description

Prepares drawings, parts lists, diagrams and related documents from general instructions such as layouts, sketches, notes, etc. which may require preparation of additional layouts under technical direction of other draftsmen, designers and/or engineers.

Responsibilities

1. Prepare engineering drawings and related documents from design layouts, etc. Establish the configuration, dimensions and tolerances of non-critical features.

Criteria: Accuracy____Time required____Presentation____Reproducibility____
Direction required____Versatility____............( )

Comments:

2. Direct and instruct other draftsmen preparing alteration notices or making revisions to drawings and accept responsibility for their work. Changes in work assignments requires supervisor's approval.

Criteria: Leadership____Accuracy____Quantity____Presentation____
Reproducibility____..............................( )

Comments:

3. Prepare check assemblies of layouts for studying spatial arrangements from specific instructions

Criteria: Accuracy____Time required____Presentation____Reproducibility____
Direction required____.........................( )

Comments:

4. Perform mathematical calculations such as tolerance checks, weights of parts and with technical direction of engineer or designer, calculate shear and tensile strength of parts.

Criteria: Analysis____Accuracy____Time required____Direction required____
....( )

Comments:

5. Advise in the preparation of drafting schedules and loads as requested by supervisor and/or designer by providing reliable estimates of the completion date of his drawings and by anticipating any delay in meeting schedules and the reasons for the delay.

Criteria: Reasonable estimates____Foresight____..........( )

Comments:

6. Maintain a thorough knowledge of Company drafting practices and have a working knowledge of materials, manufacturing assembly or installation practices and apply this knowledge to his drawings.

Criteria: Application____Understanding____Direction required____ ....( )

Comments:

7. Maintain good business relations with engineer and/or designer responsible for the design of the product and with Manufacturing and others that may be affected by his activities.

Criteria: Effectiveness____Examples set____Tactfulness____ ....( )

8. As appropriate, keep supervisor, engineer and/or designer fully informed on significant work items for which they may be held accountable such as changes in scope of work, status of job, relations, or any anticipated crises which may arise.

Criteria: Timeliness____Accuracy____Significance____.....( )

Comments:

9. Abide by, support and participate in Company programs and regulations such as security, safety, good housekeeping, cost reductions, personnel development etc., as may be appropriate.

Criteria: Dependability____Participation____..............( )

Comments:

OVERALL RESULTS.......................................( )

SUMMARY COMMENTS:

CRITERIA RATINGS	OVERALL PERFORMANCE RATINGS
(S) - Satisfactory	1. Fails to meet minimum requirements.
(+) - More than Satisfactory	2. Meets minimum requirements.
(-) - Less than Satisfactory	3. Fully satisfactory performance.
	4. Exceeds standard requirements.
	5. Far exceeds standard requirements.

APPRAISAL: Prepared by______________________________Date__________________

Reviewed by______________________________Date__________________

Employee's signature______________________Date__________________

APPENDIX "D"

INSTRUMENT USED FOR COLLECTING DATA IN DESIGN AND DRAFTING OCCUPATIONS

Date Observed________Company______________________Contact____________

Company Code:__________

Occupational Area Observed:____
(Nature of work)

Number of employees in this area:_________

System of organization:

(Note: Spacing between observed factors has been condensed on this sample format.)

Job classifications:

Hiring practices:

Training practices:

Promotion practices:

Physical facilities:

Furniture:

Equipment:

Drawing Material:

Drafting room manual and other references:

Standards:

Observed use of templates, appliques, lettering aids, and other time saving devices:

To what extent is ink used in this area?

Simplified drafting observed:

To what extent are computer devices used in this area:

Method of handling changes and revisions:

Method of checking drawings:

System of storage of drawing data:

Number of women employed in this occupational area:

Detail drafting practices: